SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1914.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS

JUNE 1914.

GENERAL PHYSICS.

1026. *Elastic Hysteresis in Steel.* **F. E. Rowett.** (Roy. Soc., Proc. Ser. A. 89. pp. 528–548, March 2, 1914.)—Describes experiments made in amplification of work by Hopkinson and Trevor-Williams [see Abstract No. 826 (1913)] to determine whether the dissipation of energy per cycle of stress increased with the frequency. Thin-walled tubes were employed in order to secure higher accuracy in the measurement of the static hysteresis. In the high-speed cycles one end of the tube was fixed, and a flywheel was mounted on the other end. By this means the tube was set in torsional oscillation, and the amplitude of vibration being recorded photographically, the rate of decay gave the hysteresis loss. The effect of air friction was investigated by attaching to the flywheel, at some distance from it, a light disc of similar dimensions and determining the new energy-loss. The air-friction loss was thus found to be of the order of 7 % of the hysteresis loss in the case of annealed steel tubes, but far more important in the case of hard steel, in which the hysteresis loss was reduced to approximately one-eighth. In the annealed tube the loss per cm.^{3} per cycle, with a stress-range in shear of 1160×10^6 dynes per cm.^{2}, was found to be about 11,000 ergs, and to vary approximately as the cube of the stress-range. In the static experiments the torque was transmitted to the experimental tube by means of a long auxiliary tube, the strain being measured by means of micrometer screw levels. In this way the tube was taken repeatedly round a cycle of some particular stress-range, and observations of stress and strain were taken at different points on the cycle. The value obtained for the ratio of mean to maximum width of the hysteresis loop was 0·506, and the author considers this ratio to be substantially independent of the stress-range. The width of the loop at zero stress was determined for a number of stress-ranges and the corresponding areas were deduced, using the constant obtained above. The areas thus calculated agreed well with the dissipation energies determined by the dynamic experiments. It was also found that by using this constant the hysteresis found by Hopkinson and Trevor-Williams in their static cycles was brought into almost exact agreement with that found by them at high speeds. A full description of the apparatus and methods used is given. J. W. T. W.

1027. *Torsional Oscillations in Nickel-wires in Alternating Magnetic Fields.* **W. Brown** and **J. Smith.** (Roy. Dublin Soc., Proc. 14. 14. pp. 215–228, Feb., 1914.)—Experiments were made with Ni-wires subjected to the influence of alternating magnetic fields of different frequencies, and it was found that with *hard* wire the damping curves with alternating fields lie below those obtained with a direct longitudinal field. When an alternating magnetic field had been on for 8 minutes and was then taken off, and afterwards a direct current through the magnetising solenoid was put on of the same value as had been previously employed, at first the deflection on scale caused by twist of wire was much less, being 1 mm. instead of 41 mm. This change, which the authors call temporary magnetic fatigue, is easily recovered from. The tables and curves given show clearly the effect of an alternating magnetic field in decreasing the damping of torsional oscillations in a soft Ni-wire. In a *hard* wire the damping due to an alternating magnetic field is *greater* than that due to an equivalent direct magnetic field, whilst in the case of the *soft* wire the damping due to the alternating field is *less* than that due to the equivalent direct field. Moreover, the damping due to a direct field is much greater in a soft Ni-wire than in a hard one; whilst the damping due to an alternating field is greater in a hard Ni-wire than in a soft one. The same effect is obtained when smaller or larger loads are on the wire. [For an account of experiments in fields produced by continuous currents see Abstract No. 788 (1911).] J. J. S.

1028. *Plastic Properties of Rock-salt.* **K. Kleinhanns.** (Phys. Zeitschr. 15. pp. 362–363, April 1, 1914.)—Rock-salt has been found to become plastic at a temperature of 150–200° C., whereas its melting-point is 820° C. The author's qualitative experiments on the bending of rods of rock-salt immersed in various liquids (water, oil, salt solutions, acids, alkalies, and organic substances) seem to indicate that when the rock-salt is immersed in a medium in which it is soluble, bending takes place far more readily and at a lower temperature than when it is immersed in a non-solvent. The author promises quantitative experiments on the same subject. J. W. T. W.

1029. *The Compressibility of Ice.* **T. W. Richards** and **C. L. Speyers.** (Amer. Chem. Soc., Journ. 36. pp. 491–494, March, 1914.)—The authors find that the compressibility of ice between 100 and 500 megabars is 0·0000120 at —7·08° C., or about one-quarter of the compressibility of water at neighbouring temperatures. It is found not to decrease remarkably as the pressure increases. There is a large temperature coefficient. A. F.

1030. *Units and Symbols, A.E.F. Committee.* (Elektrotechn. Zeitschr. 35. pp. 280–281, March 5, 1914.)—Weight = a force, mg. Mass-density or specific mass = mass/volume. Weight-density or specific gravity = weight/volume. Density = ratio of mass-density or sp. gr. of a body to that of a standard substance (usually water at 4° C.). Mass-volume = volume/mass; weight-volume = volume/weight. *Symbols*:—Energy, W; period, T; frequency of cycle, ω; frequency in alternating current, f; specific resistance, ρ; conductivity, G; electrostatic induction, D; dielectric constant, ϵ; counter-inductivity, M; magnetic flux, Φ. Unit of heat energy the international kilojoule or kilowatt-second ($= 0{\cdot}23865$ kg.-cal.$^{15^\circ} = \frac{1}{4190}$ kg.-cal.$^{15^\circ}$). A. D.

1031. *Structure of the Atom.* **E. Rutherford.** (Phil. Mag. 27. pp. 488–498, March, 1914.)—This paper and an accompanying one by C. G. Darwin [see next Abstract] are devoted to the further experimental confirmation by the author and others of his theory of atomic structure [Abstract No. 1847 (1911)]. Geiger and Marsden's experiments [Abstract No. 1296 (1913)] were in close accord with the theory. C. T. R. Wilson's photographs of trails of α-particles [Abstract No. 1885 (1912)] afford convincing evidence of great sudden deflections through encounter with a single atom. The independence assumed for these deflections of the external electrons of the atom can hold only for charged particles of very large kinetic energy, and therefore not for ordinary kathode particles or the recoil atoms from active matter. Large scattering of β-particles passing near a nucleus are to be expected, and Crowther's experiments [Abstract No. 1607 (1910)] can be generally explained on the nuclear theory. But here the interaction is not repulsive, but attractive, and Darwin has shown [Abstract No. 838 (1913)] that under certain conditions the β-particle will be drawn in a spiral orbit into the nucleus, which may explain the disappearance of swift β-particles in passage through matter. Some experiments by Marsden, soon to be published, confirm Darwin's conclusions [loc. cit.] as to the long range of the recoil H-particles. The latter's calculation of nuclear dimensions affords strong support to the author's theory, and further raises the question whether the H-nucleus may not be so small as to allow of its mass being accounted for as is that of the negative electron. It may, indeed, *be* the positive electron, with a mass entirely electromagnetic. If so, the helium atom should contain 4 positive and 2 negative electrons. Experiments by the author and Robinson show that if H or other atoms, as well as those of He, are expelled in radio-active transformations, their number must certainly be less than 1 in 10,000 of the number of the atoms. The He nucleus must therefore have a very stable configuration, capable of surviving the intense disturbance resulting from its expulsion with high velocity from the radio-active atom, so that it forms one of the units of which possibly the great majority of atoms are composed. This agrees with the radio-active evidence that atomic weight of successive products decreases by four units on expulsion of an α-particle. Atomic mass depends on the whole system of electrons, and the nucleus being so minute, the + and — electrons must be very closely packed, so that, as Lorentz has pointed out, the electromagnetic mass will depend on the interaction of their fields as well as on their number. This may account for the He-atom having not quite four times the mass of the H-atom.

On the nuclear theory the α-particle has its origin in the nucleus, and acquires much, if not all, its energy in the expulsion. The same is to be expected for the β-particles, as is Bohr's conclusion. The energy lost in β- and γ-rays during formation of RaC being above a quarter of the energy of the expelled α-particle, could hardly be derived from the electronic distribution. The conclusion of the author's theory that the number of electrons in an atom is about half the atomic weight in terms of H, is also Barkla's independent conclusion from the scattering of X-rays. But if H have one electron and He have two, the number cannot be exactly half the atomic weight in all cases, which led to van den Broek's suggestion [Abstract No. 812 (1914)], which accords with Bohr's view. As the latter has observed, gravitation and radio-activity, being unaffected by chemical or physical agencies, must be ascribed mainly or entirely to the nucleus, and the ordinary physical or chemical properties to the external electrons. On this view the nuclear charge is a fundamental constant of the atom, while the atomic mass may be a complicated function of the arrangement of units forming the nucleus. If the latter consist of H-nuclei with one charge and He-nuclei with two charges, many atoms are *a priori* possible with varying atomic masses and identical nuclear charges, as is suggested by the radio-active evidence.

G. W. DE T.

1032. *Collision of α-Particles with Light Atoms.* **C. G. Darwin.** (Phil. Mag. 27. pp. 499–506, March, 1914.)—The large angle deflections of α-particles led to Rutherford's hypothesis of atomic constitution, but his calculations involve the assumption that the atom is so heavy as to remain sensibly unaffected by the collision. The author modifies and extends Rutherford's work by removing this restriction. Calling M the mass of the particle, and m that of the atomic nucleus, there are three cases to consider, according as m is greater than, equal to, or less than M. When γ is the number of α-particles with deflection ϕ observed within a solid angle ω, an expansion is obtained for γ as a function of ϕ and M/m, and in powers of the latter. *First case:* $m > M$. This applies to all substances except helium and hydrogen. The first term of the expression gives Rutherford's expression. If M/m were as high as 1/3, as it would be for carbon, the velocity of the carbon nucleus might rise as high as V/2, V being the initial velocity of the α-particle. Such a particle might possibly be perceptible, but it is doubtful whether the shock would free the nucleus of all its electrons ; thus the experimental conditions to reveal it are rather hard to imagine. *Second case:* $m = M$. The α-particle now travels through He. In this case no particle can be deflected through more than a right angle, and to the number of α-particles must be added the He-atoms which have been set in motion so as to strike the screen, for the recoiling particles should be quite indistinguishable from the true α-particles. *Third case:* $m < M$. The α-particles travel through H, and $m = M/4$. The number of particles, as observed by the scintillations, will be composed of particles of three types, slow α-particles, fast α-particles, and the recoiling H-particles which will move more rapidly than either of the other groups. In passing through matter these will be retarded like α-particles, and Bohr's formula [Abstract No. 651 (1913)] shows that the range of an H-particle will be slightly less than an α-particle of the same initial velocity. Bohr's formula ceases to hold for small velocities, but Geiger's empirical formula $V^3 = V_0^3(1 - x/R)$ leads to the conclusion that corresponding to a range of 31 cm. of an α-particle, the range of an H-particle will be 28 cm. If an α-particle from RaC at its highest velocity strikes a nucleus straight on the initial velocity of the H-particle will be $8/5 \times 2 \times 10^9$ cm. per sec., and its range comes out at 117 cm. It would probably be greater than this, as at high speeds the range should be more nearly proportional to V^4 than to V^3. The H-particles should therefore be easily observable if they can be made to occur in sufficient numbers. Their scattering should be greater than for α-particles, for the most probable angle of scattering depends on E/M [Abstract No. 1706 (1912)], and so is twice as great for H- as for α-particles. Geiger and Marsden's experiments are strongly confirmative of the nuclear hypothesis, and no force proportional to a power of the distance other than the inverse square can give the observed relation between γ and V. An upper limit to the size of atomic nuclei is calculated from the distance of closest approach between the α-particle and nucleus. For gold the number of deflections was observed up to $\phi = 150°$, and found correct. Taking charge of nucleus 100 times electronic charge, and $V = 2 \times 10^9$ cm. per sec. gives $3{\cdot}5 \times 10^{-12}$ cm. as closest approach. In a straight-on collision with a

H-nucleus it would be 1·7 × 10^{-13} cm., which would lead to the result that the radii of the nuclei of H and He are certainly less than 10^{-13} cm.

G. W. DE T.

1033. *Remarkable Upper Air Records at Batavia.* **W. van Bemmelen.** (Nature, 93. pp. 5–6, March 5, 1914.)—Two balloons liberated at Batavia in Nov. and Dec., 1913, reached the stratosphere and encountered remarkably low temperatures at its base. In one case the minimum registered was —91·9° C. and in the other —90·9°. The former is believed to be the lowest natural air temperature ever recorded. Another remarkable feature of this ascent was that above the level of this minimum (17 km.) the temperature rose to —57·1° C. or about its usual value in the stratosphere over Europe. On only two previous occasions has the height of 20 km. been exceeded at Batavia and on one of these a similar large rise of temperature was found in the stratosphere.

J. S. Di.

1034. *The Atmospheric Obscurity of* 1912–13. **J. Maurer** and **C. Dorno.** (Meteorolog. Zeitschr. 31. pp. 49–62, Feb., 1914.)—At the beginning of 1913 the President of the Radiation Commission of the International Meteorological Committee, J. Maurer, issued a circular letter to meteorological institutes asking that observational material on the remarkable atmospheric obscurity of 1912 should be sent to him. The paper is a report on the results obtained on working up the material received in response to the letter.

The general cause of the obscurity is attributed to the volcanic eruption of Katmai in Alaska, on June 6, 1912; for successive phases of obscurity can be traced from place to place in relation to the time which had elapsed since the eruption. The first phase began on June 6 in the form of high, clear clouds which travelled from WNW. to ESE. This phase reached Zürich on June 23, Egypt on June 28, and it was not sufficiently intense to affect the records of Campbell-Stokes sunshine recorders. The max. intensity of this phase at any place usually occurred from 1 to 3 weeks after the commencement. The second phase, which was similar in character to the first, was observed on Mount Wilson on June 21. It reached Algiers on July 11 and Egypt on Aug. 8. The third phase was noted in Washington to commence from July 19 to 26, and it arrived in Egypt at the end of Aug., but this phase was lacking altogether at some stations, while at others the maximum of disturbance occurred during its course. The fourth phase spread from America to Egypt during the month of Sept. The end of the disturbance was noted in Oct. at most places. The phenomena appear to be confined to that part of the Northern Hemisphere which lies between the polar circle and the tropic of Cancer, but it is not ascertained whether they extended completely round the globe, within those limits.

R. C.

1035. *Influence of the Wind on Height of Barometer at High-level Stations.* **G. v. Elsner.** (Abhandl. d. Königl. Preuss. Meteorolog. Inst. 4. No. 3. Meteorolog. Zeitschr. 31. pp. 93–95, Jan., 1914.)—Simultaneous observations of pressure at pairs of stations—one high-level, the other low-level—are compared by reducing the reading of the barometer at the high station to that at the level of the low by the usual barometric formula, and noting the difference between the reduced value and the observed reading at the low-level station. The differences are grouped according to the wind-force observed at the high-level station, and it is found that the mean difference (low-level reading—reduced high-level reading) is nearly zero with light winds and becomes positive as the force increases. For force 5 on the Beaufort scale the mean difference for three pairs of stations is 0·3 mm.; for force 8 it is 1·3 mm.; for force 11 it is 3·5 mm.

The probable causes of the differences are discussed, and it appears that the suction effects of the wind over chimneys and on windows open to the leeside of the upper station is one of the principal of them, while the uprush of air along the mountain-slopes may contribute towards the observed results. R. C.

1036. *Meteorological Observations of Captain Scott's Last Expedition.* **G. C. Simpson.** (Review by J. v. Hann. Meteorolog. Zeitschr. 31. pp. 62–67, Feb., 1914.)—A complete set of self-recording instruments for temperature, pressure, wind velocity and direction, sunshine, atmospheric electricity, and terrestrial magnetism was erected and maintained in operation at Cape Evans. Regular eye observations of the usual meteorological instruments were made, while records of temperature and air-currents up to 8 km. were obtained by means of registering balloons and pilot balloons. In addition, absolute observations of the magnetic elements were conducted every week, also hourly observations of aurora during the whole time it was visible. Studies on meteorological optics, investigations on ice in the air and water, and gravity determinations were other subjects to which Simpson, the meteorologist of the expedition, turned his attention.

At Cape Evans the lowest temperature recorded was —45·6° C., but in a sledge journey on the ice barrier the much lower value of —60° C. was observed in July, 1911. Cape Evans was subject to a series of remarkable blizzards, which were not experienced at Amundsen's quarters (Framheim) at the same time. At the latter station 42 % of the winds were of less than 4 miles/hour, but at Cape Evans the percentage of such winds was only 30%. At Framheim the percentage frequency of higher winds rapidly fell off to zero, but at Cape Evans, after a slight falling off, there occurred a distinct increase of frequency to 7·8 % for winds of 25–29 miles/hour. Above that velocity the frequency diminished slowly, but winds above 60 miles/hour were recorded, while at Framheim there was nothing greater than 45 miles/hour. The blizzards were characterised by extreme gustiness, and also by the suddenness with which they commenced. The mean temperature at Cape Evans was —18·0° C., compared with —24·4° C. at Framheim, situated 1° further south. The considerably lower mean temperature there is probably connected with the comparative absence of wind. The potential gradient is remarkable in that it shows a max. value in the summer, whereas in the Northern Hemisphere the maximum occurs in winter. The max. and minimum values in the Antarctic occur simultaneously with the corresponding phases in the Northern Hemisphere. R. C.

1037. *Observations on the Increase of Insolation with Elevation.* **H. H. Kimball.** (Mount Weather Observatory, Bull. 6. pp. 107–110, 1914.)—A record of simultaneous observations on the radiation received at two neighbouring stations at different heights above sea-level. The first series was made at Mount Weather (1720 ft. above M.S.L.) and Trapp (720 ft.) and showed that on the four days of observation from 4 to 6 % of the radiation reaching the upper station was absorbed before reaching Trapp, 1000 ft. below. Other similar observations were made at Santa Fe, on a plateau 7000 ft. high, and at neighbouring mountain-peaks 8000 and 12,200 ft. high respectively. Great accuracy was not obtained in the readings, but it appeared that from 0·5 to 2 % of the insolation which reached the peak at 8000 ft. was absorbed before it reached the plateau, and from 2·5 to 4 % was absorbed in the case of the 12,200-ft. peak. J. S. Di.

1038. *Preliminary Results of Measurements of the Rigidity of the Earth.* **A. A. Michelson.** (Astrophys. Journ. 39. pp. 105–138, March, 1914.)—First attempts to measure the earth's rigidity, *i.e.* the resistance which it offers to change of shape, were made by G. H. and H. Darwin in 1880, employing the horizontal pendulum method for measuring change in gravitational vertical due to attraction of sun and moon, and comparing with values calculated on basis of absolute rigidity. The results obtained were very irregular and contradictory, but though the Darwins expressed the belief that such experiments were unlikely to be successful, yet in the hands of Rebeur-Paschwitz positive results were found confirming Kelvin's deductions that the earth must be considered a very rigid body. The method has since been successfully employed by Ehlert, Kortazzi, Schweydar, Hecker, and Orloff, with essentially the same result—namely : that the coefficient of rigidity is found to be of the order 6×10^{11} c.g.s. (about that of steel). In addition to the elastic yielding of any body ordinarily looked upon as solid there is a plastic yielding, characterised by a constant termed by Maxwell the "modulus of relaxation," and evidenced by a lag of the distortion of the earth relative to the forces producing it. Now such experiments as the above should be capable of determining the earth's plasticity as well as rigidity, but a discussion of the various results shows that the retardation of the phase of the observed motion relative to the phase of the disturbing forces which should always be negative, is in the majority of cases positive, so that the data further than showing that the lag is small (and therefore the viscosity high) are practically valueless. It was in the hope of obtaining results of a higher order of accuracy, as well as such directness and simplicity of apparatus as practically to eliminate all the difficulties and uncertainties which seem to be unavoidable in the use of the horizontal pendulum, that the present experiments were undertaken. The prime object of the investigation is the determination of the direction-changes of the gravitational vertical due to the attraction of the sun and moon, and as modified by the resulting distortion of the body of the earth. These may be furnished with any desired accuracy by changes in the position of the level of a liquid surface which is necessarily normal to the resultant of all the forces acting, followed by elimination of all but gravitational forces. A very sensitive method of measuring changes in level was devised using the interferometer, and a thorough preliminary investigation made to ensure its accuracy. A continuous series of observations were then conducted along an E.–W. and a N.–S. line, the apparatus comprising 6-in. pipes 500 ft. long, half-filled with water whose level could be read off through the glass sides of the end vessels. The pipes were laid in trenches 6 ft. deep, terminating in two pits, 8 ft. square and 10 ft. deep, walled with concrete. Copious experimental details are given in the paper, as well as numerous tables of observations and their graphs. There was found to be a disagreement between the E.–W. and N.–S. directions, and while Hecker, who found a similar difference, interprets this as indicating an actual difference in the earth's rigidity in these directions, Schweydar agrees with Love in attributing it to the effect of ocean tides and shows on the assumption of an ocean covering the earth uniformly to a depth of 5000 metres that the tides have the effect of increasing the elastic earth tides, so that the ratio of the observed amplitudes to the theoretical is diminished by something like

40 %. The values of the earth's rigidity n and viscosity ϵ are given as: $n = 8{\cdot}6 \times 10^{11}$ c.g.s.; $\epsilon = 10{\cdot}9 \times 10^{16}$ c.g.s. This calculation is based on the assumption of uniform rigidity throughout the body of the earth, a condition which is certainly not fulfilled, but it is clear that the earth's rigidity is greater than that of steel, while the viscosity is probably of the same order of magnitude as that of steel. The author believes this method to be capable of giving results of a high order of accuracy by recording a much longer series of observations, such being now in progress, and it is expected that the results will furnish a record of the earth tides correct to within a tenth of 1 %. The conclusions from these and similar experiments all agree substantially in refuting the old notion that the internal temperature, sufficiently high to melt most of the materials constituting the earth's crust, necessarily involves a fluid or semi-fluid earth supporting a relatively thin solid crust. Laboratory experiments are being undertaken on the interesting deduction that pressure increases the rigidity and viscosity of the materials forming the body of the earth. H. H. Ho.

1039. *Equatorial Current of Jupiter.* **T. E. R. Phillips.** (Roy. Astronom. Soc., M.N. 74. pp. 116–118, Dec., 1913.)—In the late summer of 1912 the north equatorial belt of Jupiter began to exhibit a revival of activity. In the spring of 1913, it was found that the north equatorial belt was broad and strong, with a series of very dark protuberances along its south edge and light bays between them. As these developed a number of curved wisps extended from them like festoons, completely enclosing the light areas. Finally the south portion of the zone became shaded, giving the appearance of a number of egg-shaped areas ranged regularly round the north part of the equatorial zone. Altogether 350 transits of the dark and light areas were observed, showing that the main spots were 28 in number, and that they were all drifting at an unusually rapid rate. The mean rotation period thus determined is 9h. 50m. 12·2s. The motion was not uniform. C. P. B.

1040. *Spectra of Wolf-Rayet Stars.* **J. W. Nicholson.** (Roy. Astronom. Soc., M.N. 74. pp. 118–132, Dec., 1913.)—Premising that the tendency of modern opinion is to regard the Wolf-Rayet stars as probably the earliest type known, being the first products of some form of evolution which has taken place in primitive nebulæ, the electronic theory is applied to deduce the relationships existing between the various lines constituting their spectra. The chief clue to the elucidation of the spectra analytically appears to be the remarkable constancy of ratio of wave-lengths of several pairs of lines, thus suggesting the presence of series of Balmer's type. It is then shown that it is possible to represent the typical spectrum of a Wolf-Rayet star in a manner relating it to the nebular spectrum. Excluding the lines of helium and hydrogen, practically every other line comes into the scope of these series, determined from the analysis of a system of one atom with four electrons in its ring. C. P. B.

1041. *Light-curve of Andromeda Nebula (NGC. 224).* **J. H. Reynolds.** (Roy. Astronom. Soc., M.N. 74. pp. 132–136, Dec., 1913.)—Measurements were made with a photomicrometer on negatives of the Andromeda nebula obtained with a 28-in. reflector (10 ft. focal length), on Oct. 7, 8, and 17, 1912. The results are tabulated and also given in the form of a curve showing the variation in intensity from the centre of the nebula outwards. The curve is remarkably similar to the curve having for its equation $(x+1)^2 y = \text{const.}$ C. P. B.

LIGHT.

1042. *Infra-red Monochromatic Filter.* **F. Paschen.** (Ann. d. Physik, 43. 6. pp. 858–860, March 20, 1914.)—The author has succeeded in isolating many spectral lines monochromatically in the region around 1 μ by using a combination of Wratten and Wainwright's filters F29 (or 28) and H45 (or 44) in conjunction with a 1-cm. water-cell. The combination, cemented between optical glass plates and made watertight by Canada-balsam and tin-foil, is preferably placed inside the water-cell. The region of max. transparency, 60–70 per cent., extends from about 0·85 to 1·15 μ.

With a helium lamp 69·8 per cent. of the ray at 1·083 μ is transmitted, and with a quartz cadmium lamp 69·5 per cent. of the ray at 1·039 μ, whereas, for instance, Wood's infra-red filter transmits only 18 per cent. of the former ray. Several other good combinations can be obtained. C. S. G.

1043. *Developments in the Construction of Periscopes for Submarines.* **F. Weidert.** (Jahrbuch der Schiffbautechn. Gesell. pp. 174–227, 1914.)—The utility and safety of a submarine depend on the use of a reliable and inconspicuous apparatus making visible more or less of the surrounding surface of the sea to the officer in command, yet the periscope was the last of the essential components of a submarine to be brought to that perfection on which the practicability of effective submarine attack now depends. The author traces the development of various methods and apparatus for seeing the surface from a vessel submerged below the latter. The most rapid and important improvements in periscope design and construction have been made during the last ten or twelve years, and relate to increased field of view; brightness and sharpness of picture; convenience of observation; and the incorporation of range-finding devices. Purely optical improvements have been accompanied by improvements in mechanical design and manipulating gear. The adverse effects of boat and sight-tube vibration and of water on the surface prism or window have been reduced. The author describes and illustrates the construction and use and compares the relative merits and demerits of simple reflecting sight-tubes and bent telescopes of various types. Lens devices alone give a sufficiently large field of view while permitting the use of long and slender sight tubes. In modern apparatus the field of view is increased by bringing the eyepiece optically nearer to the objective. Numerous illustrations show the construction of the light-path in various periscopes. A magnification of 1·5 is found to convey the impression of natural magnitude to normal eyes; a 1:1 ratio leads to distances being over-estimated. Special devices giving a magnification of 5 or 6 are used to permit details to be distinguished. A fairly large focal area is desirable in order that as bright an image as possible may be obtained at all times and in order to reduce fluctuations of brilliancy (as seen by the observer) when the apparatus is subject to vibration. About 4% loss is suffered at each surface by reflection of light falling perpendicularly on to clear polished glass; the actual loss as a percentage of the original increases less rapidly as the number of surfaces increases. The reflection loss in a periscope system of the Grubb type may be 57·5 % and more if the glass surfaces be dirty or wet: the absorption loss may be 28·5 % leaving about one-third of the incident light available at the eyepiece. Within limits, expansion of the observer's pupil compensates for this loss. Excessive absorption, blurring by multiple reflection, and cumulative optical errors make it impracticable to employ more than 4 telescope systems in series. The greater part of the sight tube must be of at least that diam. required to prevent vibration and deflection, but the upper portion of tube (projecting above the surface) may be much smaller. The mounting of the ocular and arrangements for erecting and rotating the sight tube are described and illustrated. Means are described whereby rotation of the whole tube may be eliminated ; this operation demands considerable effort owing to the water pressure exerted on the tube when in motion. The direction of sight at any moment is then indicated by a scale and geared pointer visible in the field of view itself. The objective head is usually tested under 10 atmos. water pressure and the ocular head under 1 atmo. external and 10 atmos. internal pressure. Means of removing moisture condensing on the lenses, etc., are described in the original.

The first instrument of the cleptoscope class providing an image on a matt screen was built in Germany in 1903-4. The advantages and limitations of such instruments are discussed. The advantages of a combined "ocular-matt disc" instrument are indicated, and the 1909 Goerz model is illustrated and described. The advantages of rotating-objective bifocal periscopes are compared with those having interchangeable oculars, in providing two or more ratios of magnification : a supplementary telescope may be used. Various panoramic periscopes are described and illustrated in detail. The utility of a Dove prism, in providing an erect image in a stationary eyepiece while the objective is rotated, is explained. Alternatively two confocal cylindrical lenses may be used. Mangin's ring mirror lens is applied to obtaining an annular image of the whole horizon in a single eyepiece : the word "periscope" applied originally to this apparatus alone. Aldis' lens uses a hyperboloid mirror surface to eliminate aberration ; Goerz's spherically-corrected ring-mirror lens is described. The latter provides an annular image of the whole horizon and a central enlarged view of any desired part of the horizon, the whole of both images being visible at the same time. The most serious of the several objections urged against this instrument is the difficulty of determining and changing bearings quickly by reference to the panoramic image, which is greatly distorted. Binocular periscopes offer important advantages and may comprise two independent sight tubes. Small diameter can be preserved in long-tube binocular instruments by using only a single objective and splitting the light received by suitable prisms near the eyepieces ; this halves the light passing to each eyepiece but usually still provides more light than the normal eye can receive. The arrangement and use of a compass card in the head of the sight tube is illustrated and explained ; such a card is useful in taking bearings and as a control over or substitute for the navigating compass. The final section of the paper deals with range-finding attachments. The simplest device is the telemeter plate, which in its most convenient form shows, say, the height of a funnel as a percentage of the range. A more convenient and accurate device is the double-image micrometer by which part of the image can be displaced through its own height with reference to the other part, and the range then read directly on a scale (the actual height of the object being known). R. E. N.

1044. *Refraction of Light in Space Grating.* **E. Buchwald.** (Phys. Zeitschr. 15. pp. 331-337, April 1, 1914.)—A research is described on the refraction of visible light by a space grating structure which gives an interference effect of the type of the X-ray patterns obtained with crystals in Laue's arrangement, *i.e.* similar to an incomplete crossed grating spectrum. Photographs of the effect are reproduced. A comparison of the results of the research with Laue's theory shows that the agreement can only be regarded as qualitative and not in general as quantitative, and no definite conclusions with regard to wave-length and grating constant can be drawn from the photographs. The source of the differences may be sought in the shadowing effect of the refracting particles. [See also Abstracts Nos. 1686 (1913) and 872 (1914)]. A. W.

1045. *Plane Grating.* **F. Biske.** (Phys. Zeitschr. 15. pp. 327–331, April 1, 1914.)—A paper discussing theoretically the shape of the rulings on a plane grating to concentrate as much energy as possible into a single-order spectrum, also dealing with the energy distribution from the standpoint of the diffraction theory. A. W.

1046. *Refractive Indices of Gaseous Mixtures.* **S. Valentiner.** (Deutsch. Phys. Gesell., Verh. 16. 7. pp. 363–366, April 15, 1914.)—Describes a fresh examination, by the method of F. Richarz and E. Neumann, of the experimental results found by the author and O. Zimmer [Abstract No. 435 (1914)] for the refractive indices of gaseous mixtures. A brief outline of the method is given. The deviations of the experimental results from those calculated according to the ordinary law are treated in five different ways to provide five values of a function W. If the mean value of W is small the deviations are probably due to accidental error, while as W approaches unity the probability of a true departure from the law increases. In conformity with the conclusions arrived at in the original paper [*loc. cit.*], such true departure was found in the case of a CO_2—H mixture, but not for the He—Ne—H. J. W. T. W.

1047. *Interference Experiments in a Rarefied Gas.* **F. P. Kerschbaum.** (Phil. Mag. 27. pp. 397–415, March, 1914.)—A brief discussion is given of the radiation hypotheses of Planck and Thomson, and an attempt is made to explain from the unit point of view the interference experiments hitherto known. Interference experiments are then described where the source of light and the interference apparatus are in the same highly evacuated vessel. The whole vacuum vessel was made of transparent quartz-glass. A tube 600 mm. in length, 15 mm. internal diam., has a cylindrical ground surface on the outside at one end. Over this ground surface a short brass cylinder fits tightly, and the end of this cylinder is closed by a brass disc bearing a slit which has to act as the line source of light. This slit was 0·02 mm. in width, 12 mm. high and 15 mm. in length. The other end of the quartz-glass tube was provided with two slots, 12 mm. long, 0·05 mm. wide, and 1 mm. apart, cut in a thin sheet of copper; these slits were arranged to give the greatest possible intensity and distinctness to the fringes seen when a source of light was placed behind the first slit. The whole tube was then pushed into another quartz-glass tube, the two fitting with a ground joint, and the double slit just reaching to the end of the outer tube, which was closed with a plane-parallel plate of quartz-glass fused on the tube. The outer tube at the other end had a second ground joint and was attached to a sort of cap whose interior formed a chamber in which resonance radiation of Hg-vapour was produced by a Hg arc-lamp of special construction. The whole apparatus was pumped out with a Gaede pump, and it is believed that the partial pressure of gas finally left after liquid-air cooling was under 0·000001 mm. A telephoto camera was used for photographing the fringes, and was brought right up to the plane-parallel plate of the vacuum vessel. At the low pressures used no trace could be found of any diminution in number or distinctness or intensity of the fringes produced, compared with the appearance of the fringes given by the same apparatus at atmospheric pressure. The experiments show that we have no reason to assume that a subdivision of light-units is taking place when these units pass through matter. The resonance hypothesis is therefore not able to reconcile the existence of interference phenomena with the conception of units dealt with in the earlier part of the paper. But we are not forced by this experimental result to assume the hypothesis that the energy of the elementary radiator is only spreading in spherical waves, if we can develop a conception of a unit which produces effects similar to those of waves when falling upon an interference arrangement. Such a conception seems possible, and one is suggested based on some ideas of J. J. Thomson. An atom model is assumed with electrons rotating round a central body, lines of force originating from the electrons, and disturbances travelling along them. A line of force originating normally to the plane of rotation of the electron will not have much motion, and a train of oscillations travelling along this line will be in something like a straight line. But on a line of force in the plane of the rotation of the electron, a train of oscillations will not be emitted as whole in a certain direction; if the motion of the electron is only rapid enough the train of oscillations will be emitted in a spiral with a very considerable number of turnings. These spirals spread. As a finite source of light will emit them in random directions, these spirals will produce effects similar to those of spherical waves when falling upon an interference apparatus. From the fact that very distinct interference fringes can be obtained experimentally, we should have to deduce that the energy emitted from a source of light in straight trains is very small compared with the energy emitted in such spirals. These views form, perhaps, the foundation for a combined explanation of the purely optical phenomena and of the ionisation effects. [See also Abstract No. 900 (1911).] A. W.

1048. *Aberration in a Dispersive Medium and Airy's Experiment.* **J. Walker.** (Phys. Soc., Proc. 26. pp. 82–84, Feb., 1914.)—The view recently adopted by Rayleigh that in the case of aberration we are concerned with the group-velocity instead of with the wave-velocity, makes it necessary to consider the experiment of Airy, in which he measured the angle of aberration with a telescope filled with water. A modification of Rayleigh's explanation of this experiment leads to the result that the angle of aberration thus determined corresponds to an angle $\mu^{-1}v/U$ measured in air. The same result is obtained from an analytical investigation, and a numerical calculation shows that the increase in the angle is about 1 per cent.—an amount that is probably too small to be detected. AUTHOR.

1049. *Interference Images of a Grating Line.* **J. Kern.** (Phys. Zeitschr. 15. pp. 337–342, April 1, 1914.)—A mathematical treatment; does not admit of brief abstract. [See also Abstracts Nos. 1963 and 1964 (1913).] A. W.

1050. *Formation of Images by Means of an Opaque Disc.* **A. W. Porter.** (Phil. Mag. 27. pp. 673–674, April, 1914.)—" In spite of the prominence given in treatises on Physical Optics to the existence of the bright spot at the centre of the shadow formed by a point source and a circular disc, it does not seem to have been recognised that, as ordinarily exhibited, the bright spot is in reality an image of the source of light. The source is never a point in practice, and the contour of the bright patch is simply the locus of the diffraction spots formed by the various points on the contour of the source of light." The author had long been impressed by the very sharp boundary of the bright patch when obtained with a pinhole source, and the explanation recently occurred to him. To test the matter, he took a circular source about 9 mm. in diam., with a thin wire stretched across its centre, illuminated from behind by an electric arc, and found that, as he suspected, the patch was transformed into a sharp image of the bright opening with its dark bar. It is thus possible to obtain sharp images of small objects, using an opaque disc instead of a lens. In conjunction with E. T. Paris, he has taken photographs of a triangular opening, one of which is produced in the original article. The superiority of the optical definition in this case to that in the complementary case of pinhole photography is noteworthy. It would have been impossible to obtain a photograph of the triangle with an aperture of the same size instead of a disc. The length of each side of the triangular source was 0·21 cm., and of the image, 0·58 cm. The author calculates theoretically the size of the true bright spot for a source on, or near, the axis of the disc, and applying the result to the case in question, finds that the side 0·58 of the image is about 40 times as long as the diameter of the calculated bright spot. There is advantage in placing the disc fairly near to the source. A. E.

◆ 1051. *Brightness of Optical Images.* **P. G. Nutting.** (Washington Acad. Sci., Journ. 4. pp. 129–134, March 19, 1914. Photographic Journ. 54. pp. 187–191, April, 1914.)—An abridged paper, in which the author states the formula giving the relative brightness of image and object, for any values of *u*, *v*, lens aperture and focal length. Experimental determinations of the relation, using various well-known lenses, are described; by comparing the results with the formula the percentage transmissions of the lenses are deduced. T. H.

1052. *Stereoscopic Effects without a Stereoscope.* (Science, 39. pp. 17–18, Jan. 2, 1914.)—A background is prepared so as to scatter light in such a way that it appears white to the one eye, black to the other, when the observer takes up a proper position. On this are superposed two film images, the one a positive transparency, the other a bleached negative. To the one eye the one of these is invisible, to the other the other. The effect of what is seen is a blend in stereoscopic relief. A. D.

1053. *Control of Photographic Tone-values.* **A. Kapteyn.** (Photographic Journ. 53. pp. 285–296, Dec., 1913.)—To use a negative which presents contrasts beyond the grasp of the printing process employed, supplement it by putting on the negative a perfect positive image, obtained by contact and placed in true contact with it. Practical difficulties as to registration and as to the optical consequences of imperfect contact, and how to overcome these, are dealt with. Applications to cases of difficulty are discussed. A. D.

1054. *Speed of Plates; Testing by Daylight.* **W. B. Ferguson.** (Photographic Journ. 53. pp. 297–307; Discussion, pp. 307–308, Dec., 1913.)—A practical approximate method, applicable to colour-sensitised as well as ordinary plates, of ascertaining relative speeds by comparing the apparent inertias on a Hurter and Driffield diagram. As an equivalent for daylight it was found that an 8-c.p. Osram lamp, run at 10 volts, with a Wratten's No. 79 light-filter gave what was required. A. D.

1055. *Direct Photographic Positives.* **G. A. Perley, T. J. Twomey,** and **H. A. Robinson.** (Journ. Phys. Chem. 18. pp. 185–212, March, 1914.)—The conditions for the best direct positive by development are critical, and slight variations cause either fog or a negative. The critical conditions are found for a large number of practical cases. Example: Imperial special lantern plate; exposure through a lantern-slide of average density, 8 seconds at 18·5 in. from a 15-c.p., 6-volt tungsten lamp worked at 2·5 volts; temperature 20–21°C.; development 2 to 2½ minutes in the following: water 9·3 gm., sodium sulphite 0·234, hydroquinone 0·034, allylthiocarbamide 0·0014, sodium hydroxide 0·0026, all in gm. per sq. in. of surface: result, an excellent positive of purple colour. A great range of tints is obtainable by using different developers. The type of thiocarbamide employed makes a great difference; apparently the unexposed portions of the emulsion are more soluble than the exposed, and are locally dissolved and locally reduced by the thiocarbamide to coloured colloidal silver before an excessive negative can be developed. A. D.

1056. *Light-emission Model.* **E. Gehrcke.** (Phys. Zeitschr. 15. pp. 123–127, Feb. 1, and pp. 198–201, Feb. 15, 1914.)—Lenard some time ago put forward the view that the light of phosphorus was produced by an electron shot out from the atom a considerable distance and then oscillating about its old equilibrium position. Recently N. Bohr has succeeded in formally deriving a series formula. The present author seeks to obtain this result by a simpler way. For this purpose the following general assumption is made: If an electron through any cause possesses, relative to the nucleus of the atom, the kinetic energy $\frac{1}{2}mv^2$, and if this energy is expended on the generation of ν vibrations per sec., then shall we always have the relation $\frac{1}{2}mv^2 = h\nu$. This relation is apparent and fairly well established from the experiments on the secondary electron rays from ultra-violet light, Röntgen-rays and γ-rays; whether it involves a notable contradiction of the classical mechanics and electrodynamics is a question that need not be further considered here.

Secondly, the author assumes that the electron has a position of stable equilibrium at a distance r_1 from the positive nucleus, being pulled in from positions of greater distance and prevented from coming infinitely near to the nucleus.

Further, the return of the electron to this equilibrium position r_1 cannot commence from any and every distance but only from certain determinate distances r_2, r_3, r_4. . . . These distances are connected with each other by a certain small distance r_0 such that $r_p = p^2 r_0$, where p is any integer. Thus $r_1 = 4r_0$ and $r_3 = 9r_0$. The equation for the frequency is then derived in the form $\nu = (2\pi^2 me^4/h^3)\ [1/9^2 - 1/p^2]$ which gives the Balmer series in agreement with Bohr.

It is further shown that this model atom agrees with the effect of an electric field on the spectrum lines recently observed by J. Stark [Abstract No. 288 (1914)]. It would also show the Zeeman-effect on the Lorentz theory. E. H. B.

1057. *Model of Light Emission.* **E. Gehrcke.** (Phys. Zeitschr. 15. pp. 344–348, April 1, 1914.)—Discusses a model atom in which the electrons are arranged in a number of orbits, each set of orbits occurring on the surface of a given sphere. Thus there are 3 such orbits on an inner sphere, 5 orbits on an intermediate sphere, and 8 orbits on an outer sphere. By this model it is sought to account for the series lines of the spectrum. [See preceding Abstract.] E. H. B.

1058. *Intrinsic Optical Activity.* **G. H. Livens.** (Phil. Mag. 27. pp. 468–473, March, 1914.)—There are three possible forms of the electron theory of the intrinsic optical rotatory power found to be associated with certain substances: the first is that given by Drude in his "*Optik,*" the second is a mixture of this one and the third, which latter was developed by the author following a suggestion from Lorentz. The object of the present paper is to decide between the three. After making this examination the author concludes that the test of reality results entirely in favour of the third theory, and the formula deduced from it may therefore be taken as best representing the facts. E. H. B.

1059. *Kathodic Decomposition of the Fourth Line of Balmer's Series and Probable Regularities.* **A. Lo Surdo.** (Accad. Lincei, Atti, 23. pp. 326–328, March 1, 1914.)—The author extends his previous observations [Abstract No. 666 (1914)] to the fourth line, H_δ, of Balmer's series, which lies so far towards the violet end of the spectrum that the method of direct vision was replaced by a photographic method. The mercury-vapour from the pump was prevented from entering the observation tube by the insertion of a condenser cooled in liquid air, and a displaceable kathode was employed so that it could be used for a number of photographs. Several lines due to impurities make their appearance, but these cannot be confused with the decomposed elements if an image of the tube placed parallel to the slit is projected on to the latter. The decomposed elements exhibit their max. separation near the kathode and gradually reunite as the intensity of the electric field diminishes. They have therefore a fan-shaped configuration, which permits of their certain distinction from other non-inclined lines and also indicates the line from which they originate. The results obtained with the four lines are given in the following table, which shows their relation to the rule expressed by Balmer by the equation, $1/\lambda = a - 4a/n^2$, which for $n = 1$ or 2 gives results which cannot be interpreted, but for $n = 3, 4$, etc., gives the wave-lengths corresponding with the terms 1, 2, 3, etc.:—

Line	H_α	H_β	H_γ	H_δ
λ	6562·1	4860·7	4340·1	4101·2
n	3	4	5	6
Total number of components	3	4	5	6
Order of line in series	1	2	3	4
Components with normal vibrations	1	2	3	4

T. H. P.

1060. *Decomposition of the Red Hydrogen Line in the First Kathodic Layer.* **L. Puccianti.** (Accad. Lincei, Atti, 23. pp. 329–330, March 1, 1914.)—The author confirms the results obtained by Stark [Abstract No. 288 (1914)] and by Lo Surdo [see Abstract No. 666 (1914)] for the lines H_α, H_β, and H_γ [see also preceding Abstract]. T. H. P.

1061. *Comparison between the Kathodic Decomposition of the First and that of the Second Line of Balmer's Series.* **L. Puccianti.** (Accad. Lincei, Atti, 23. pp. 331–333, March 1, 1914.)—The author finds that, if the separations of the extreme components produced by kathodic decomposition of the lines H_α and H_β are represented by $\Delta\lambda_\alpha$ and $\Delta\lambda_\beta$ respectively, these magnitudes are connected by the simple relations, $\Delta\lambda_\beta/\Delta\lambda_\alpha = 3/2$ and $(\Delta\lambda_\beta/\lambda_\beta):(\Delta\lambda_\alpha/\lambda_\alpha) = 2$. These relations cannot both be rigorously true, since the value 3/2 for the former would give 81/40 for the latter. T. H. P.

1062. *Absorption of Light by Uranous Chloride in Different Solvents.* **T. R. Merton.** (Chem. Soc., Journ. 105. pp. 23–27, Jan., 1914.)—Marked changes are produced in the spectrum of uranous chloride by the addition of hydrogen chloride to its solutions in different liquids. These phenomena cannot readily be explained without assuming that different kinds of aggregates coexist in the solutions, and that the vibrators responsible for the less refrangible bands are situated in different aggregates to those responsible for the more refrangible bands. T. M. L.

1063. *Spectrum Lines for Monochromatic Illumination.* **R. W. Wood.** (Phil. Mag. 27. pp. 524–530, March, 1914. Phys. Zeitschr. 15. pp. 313–317, April 1, 1914.)—In order to obtain pure monochromatic illumination of great intensity the author adopts a polarisation method which allows one or more lines to be removed from a spectrum with practically no loss of light. Instead of nicols two double-image prisms are used in conjunction with a Dunoyer condenser, between the halves of which a large quartz plate is placed. This plate must be between 25 and 40 mm. in thickness, and, for sodium light, plane parallel to considerably within 0·032 mm. By this arrangement it is possible, for instance, to obtain a focus (1 × 3 cm.) of one or other of the D-lines at will by suitably rotating the quartz plate. Brazilian quartz alone appears to have the necessary optical purity for making a suitable plate. C. S. G.

1064. *Intense Sodium Flame.* **R. W. Wood.** (Phil. Mag. 27. pp. 530–531, March, 1914.)—A sodium flame with an intensity approximating to the oxy-hydrogen sodium flame is produced by using a few pieces of the fused chloride on a fragment of a Welsbach mantle placed on the grill of a Méker burner. C. S. G.

1065. *Different Spectra of Mercury, Cadmium, and Zinc.* **J. de Kowalski.** (Comptes Rendus, 158. pp. 788–789, March 16, 1914.)—The same metals under different discharges are known to give different spectra. A method is described by which all the different spectra can be reproduced in the same experiment. A luminous discharge is produced in the vapour of the metal contained in a quartz tube by means of copper wires, carrying high-frequency current, wound round the tube. The metal is contained in a bottom annex and the pressure of its vapour is altered by heating this. At high pressures (< 10 mm.) isolated discharges take place due to the electrostatic effect of the field, but at low pressures these change into annular discharges in consequence of the electromagnetic action of the current. The luminosity is feeblest for Cd and greatest for Hg, and when analysed consists of a faint continuous spectrum interspersed with brilliant lines of the ultimate spectra. Different lines appear at different pressures. On further lowering the pressure the annular discharge increases greatly in brilliancy, and between narrow limits splendid band spectra make their appearance. In Hg-vapour these appear below 0·2 mm. and are very rich in lines; they cannot be attributed to impurities.

The vapours of Cd and Zn, like that of Hg are found to fluoresce under the action of the X-rays when their density is about equal to that which in an electromagnetic field would produce a continuous spectrum. Fuller measurements will be published later. C. S. G.

1066. *Structure of the* D_1 *and* D_2, *Lines observed in a Bunsen Flame with different Sodium Compounds.* **K. I. Ivanov.** (Russian Physico-Chemical Soc., Journ. 45. pp. 125–141 [Physical Part], 1913. In Russian.) —The classic way shown by A. A. Michelson [Phil. Mag. 34. p. 280] is correct only when the intensive curves are symmetrical in relation to the middle of the line, which does not happen in very many cases, and the use of a thermo-element for this purpose is a very difficult matter. The aim of the present investigation was to find if on the basis of a correct structure of D-lines, received by the use of Koch's and Brotherus' method [Abstracts Nos. 759 (1911), 1858 (1912)], it would be possible to determine whether the sodium lines are constant or not. When the brightness of a yellow light is observed it is only necessary to use, first NaBr, and next Na_2CO_3 in a Bunsen burner; and it will be found that in the former case the light is brighter. For the examination of the spectrum the author used a large flat Rowland grating (12·7 × 9 cm.) having about 14,000 lines to the inch; telescope, 280 cm. long; diam. of object-glass, 8·2 cm. A lens of 5·5 cm. focus was used to reflect the light on to the slit of the spectroscope (height, 1 cm.). The separation of the D-lines on the sensitive plate in the spectrum of second order was 5·8 mm. To measure photometrically the absorption lines he used Hartmann's microphotometer, and the mirror enclosed in the glass tube gave a surface of 0·600 × 0·084 mm.^{2} on the plate. The scale of intensity was established by the method of Voigt (Brotherus loc. cit.). This intensity of light changes from bright to dark streaks according to law best expressed by the formula $i = i_0 . \cos^2 \pi x/l$. As photographic plates taken from the same packet often differ in sensitiveness it was necessary to compare all the spectral lines on the photograph, on one plate, with a scale of intensity; and as only 6 spectra could be taken on one plate he used the following: NaI, NaBr, NaCl, $NaNO_3$, Na_2CO_3. Wratten and Wainwright panchromatic plates were used, the exposure given being 3 hours. Though the spectroscope was protected from outside light and diffusion was possible only through the slit—which in all tests, when it was desired to arrive at constant intensity in the D-lines, was 0·081 mm. wide—the experimental room was kept in perfect darkness. The plates were developed in the usual manner. During the long exposure it was important that the burner should not only burn perfectly, but that no change should take place in the adjustment. For this reason the temperature of the air near the spectroscope was constantly kept under observation, both before and after exposure. The Na salts were introduced into the flame as solutions, and these were used as concentrated as possible; thus NaI, 32·3 %; NaBr, 22·3 %; NaCl, 12·6 %; $NaNo_3$, 18·5 %; Na_2CO_3, 11·5 %. Having regulated the stream of air and gas into the burner at 2·5 m. per min. a flame was obtained in which, through the insufficiency of air, combustion was imperfect and extension reduced. The intensity of the D-lines was so weak that a very long time would have been required to obtain measurements of the blackening on the plate. It was necessary to widen the slit to 0·1 mm.; but in this state t was hardly possible to obtain a photograph giving a true distribution of the intensity in the D-lines. One experiment gave the maximum intensity as below:—

	D_2.	D_1.
NaI	54·4	45·5
NaBr	46·0	41·0
NaCl	42·4	36·4
Na_2CO_3	40·7	33·8

When these results are compared with Thomson's tables (Landolt-Börnstein, p. 484, 1905) which give NaI, 69·1; NaBr, 85·7; NaCl, 97·7; Na_2CO_3, 272·6, we can see that in flames with a low temperature the more solid compounds give a weaker light. The thermal conditions then govern the emissive power of the D-lines. A more generous supply of air was then given to the burner, and in order that the amount of sodium should remain near that first used the solutions were so diluted that instead of 5 % they contained only 3 % of Na. These differences in the usual type of Bunsen burner can only be ascribed to differences of temperature in the flame. A Makerof lamp gives a flame with a constant temperature which is a little higher than that of a Bunsen burner. The same amount of air (6 litres per min.) was allowed and of Na (0·078 mgm. per sec.); lighting gas used was only 1·9 litres per min. During the whole length of burning the temperature was 1720° C. The lines obtained with the different salts of sodium were alike.

The author arrives at the conclusion that there are two probable explanations: (1) That the atoms of Na form the D-lines only during the very short time that they are free; or (2), what is more probable, that the system by which the D-lines are formed is inherent in the Na-atom itself: that molecular combinations have no influence over the structure of D-lines. This phenomenon still requires a satisfactory theoretical explanation. I. P.

1067. *Spark Spectra of Nickel and Cobalt in the extreme Ultra-violet.* **L.** and **E. Bloch.** (Comptes Rendus, 158. pp. 784–787, March 16, 1914.)—The spark spectra of these metals in the region 2300 to 1850 Å. is obtained with a quartz spectrograph on plates specially sensitised according to Schumann's directions. The lines are read with a dividing machine in International units, using the Cu and Al lines in this region as the comparison spectra. An accuracy of about 0·1–0·2 Å. is obtained throughout. Discussion of the spectra is reserved till later. C. S. G.

1068. *Arc and Spark Spectra of Tin.* **R. Arnolds.** (Zeitschr. wiss. Phot. 13. pp. 313–331, March, 1914. Extract from Dissertation, Bonn, 1913.)—The arc and spark spectra of tin are remeasured photographically on the International unit basis (red Cd line) between λ7800 and λ2069 by means of a Rowland grating, and are compared with former measurements. The lines show a very good agreement with values calculated on the Kayser and Runge basis but conform indifferently to those calculated from van Lohuizen's formula. C. S. G.

1069. *New Determination of Optical Parameters in the Case of the D-lines.* **K. I. Ivanov.** (Russian Physico-chemical Soc., Journ. 45 pp. 109–124 [Physical Part], 1913. In Russian.)—Voigt in his "Magneto- und Elektro-optik" (p. 108) has put forward a method in which the "width" of the streaks is estimated at 2 μ. This method, however, on a more reliable photometric determination of the width of the absorption lines does not give us the expected sizes of V′ (one of Voigt's parameters), and the author hence gave up the idea of using it to determine V′.

Take a flame of unit thickness upon which a light impinges from somewhere, giving a continuous spectrum, its intensity in the region of the investigated line being constant and equal to I. The weakened intensity from absorption being designated i, we receive then $-4\pi/\chi\int_0^l nx\,dz, i = Ie = Ie^{-p}$. For every stratum of nx the bulk nx is falling off from the maximum determination $nx = \rho/2n_0V_0V'$ to a half; if away from the middle of the streak, to $\mu = \frac{1}{2}V'$. If V′ was constant for all layers of the flame, it would mean $\mu = 0$ and $i = i_1 = Ie^{-\bar{p}}$..., where $\bar{p} = 4\pi/\chi\int_0^l \overline{nx}\,dz$; the opposite of this $\mu = \frac{1}{2}V$. $i = i_2 = Ie^{\frac{1}{2}p}$; and we would obtain the following equations: $i_1/I = (i_2/I)^2$, $i_2 = Vi_1I$. The second equation enables us to find V′ when the distribution of the intensity in the absorption band is photometrically measured. It is sufficient to find two points of intensity i_2 on the curve; the distance between them gives V′.

Since the magnetic field into which the flame is placed to determine ρ may deform it, the author states that when the non-polarised white light passes through in the direction perpendicular to lines of coloured flame in the magnetic field he received instead of one streak with a density V_0 two absorbing streaks with densities of $V_0 \pm \mu_0$ and the determinations are $i_1 = I/2(1 + e^{-\bar{p}})$ and $i_2 = I/2(1 + e^{-\frac{1}{2}\bar{p}})$; which makes $i_2 = I/2 + \sqrt{(i_1 - I/2).I/2}$. In the observations of the magnetic rotation of the plane of polarisation he used NaI, NaBr, NaCl, $NaNO_3$ and Na_2CO_3, all containing 5 % of Na. To test the dependence of $\bar{V}'$ on the density of steam he introduced into the same flame solutions of NaBr containing 5 %, 5/2 %, 5/4 %, 5/8 %, 5/16 % Na. Definitions of $\bar{V}'$ were as follows: $40{\cdot}2 \times 10^{10}$; $36{\cdot}0 \times 10^{10}$; $30{\cdot}5 \times 10^{10}$; $22{\cdot}7 \times 10^{10}$; $15{\cdot}5 \times 10^{10}$ instead of the expected values 48 : 35 : 28 : 22 : 17. n_0 may be in all tests of this kind taken as unity. To measure χ and μ the author used a microscope of small magnification, which could, with the help of two micrometric screws, be turned into two perpendicular positions. Three points were chosen in each crook, and the distances measured to an accuracy of 0·01 mm. from the primary middle of the absorption band and interference streak. The first distance gave μ, and the second χ. In the case of NaBr it was found that $\bar{\rho} = 6{\cdot}27 \times 10^{23}$. With NaI, NaCl, $NaNo_3$, Na_2CO_3, the average for Na salts was $\bar{\rho} = 6{\cdot}33 \times 10^{23}$. In all cases where the value of $\bar{V}'$ is ascertained by photometric instead of optical processes [which were used by Hallo and by Geiger. Abstract No. 2040 (1907)] the numbers in definition were higher. In this way the dimension of $\bar{V}'$ is correctly ascertained within 2 to 3 %. Taking $\mu = 0$, $\rho = 33 \times 10^{23}$, $V_0 = 3{\cdot}2 \times 10^{15}$, $\bar{V}' = 40{\cdot}5 \times 10^{10}$, $n_0 = 1$ we find the maximum dimension of nx_m defined as $\overline{nx}_m = \rho/2n_0V_0\bar{V}' = 2{\cdot}4 \times 10^{-4}$ and by the use of the formula $\delta = \bar{V}'/2.\bar{i}$, we find the decrement of δ for flames containing respectively the greatest and smallest quantities of Na to be—

$$\delta_M = 3{\cdot}9 \times 10^{-4};\ \delta_m = 1{\cdot}5 \times 10^{-4}.$$

I. P.

1070. *Effects of Electric and Magnetic Fields on Spectra.* **N. Bohr.** (Phil. Mag. 27. pp. 506–524, March, 1914.)—After summarising the main outlines of his theory of atomic structures [Abstracts Nos. 15 and 811 (1914)], the author shows how it suggests explanations of Stark's recent discovery [Abstract No. 238 (1914)] and of the Zeeman-effect. On this theory an electric field may be expected to influence the stationary states of an atom, *e.g.* H, and therefore its energy in these states, but not the mechanism of transition between the states. Assume a nucleus of infinite mass compared to that of electron, and let an electron orbit be originally circular, but deformed by an electric field. The effect in time of even small electric force, unless accurately perpendicular to the orbital plane, will be considerable. At any instant the orbit may be regarded as an ellipse with the nucleus as focus, and the field effect as gradual variation of direction of major axis and of eccentricity, during which the length of the major axis will remain approximately equal to the diameter of the original orbit. Two stationary orbits are then found possible, consisting of a straight line on either side of the field axis and parallel to it, and orbits near these limiting cases are found to be nearly stationary. A formula is then found holding for high values of n, where $n_1, n_2 \ldots$ are the whole numbers in the equation $f_r(n) = \mathrm{K}\phi_r(n)/n^2$ which, according to Balmer, Rydberg, and Ritz, expresses the frequency of the lines in the line-spectrum of an element, K being a universal constant, and ϕ a function which for large values of n approximates to unity. For the mechanical interpretation of the calculations it is then merely necessary to assume that the eccentricity is very nearly unity for large orbits, which formula gives for every H-line two components placed symmetrically with regard to the original line, their difference of frequency being given by the equation $\Delta\gamma = 8h\mathrm{E}(n_2^2 - n_1^2)/4\pi^2 em$, where E is the external electric force, n_1 and n_2 are the values of n for two successive stationary states, m and $-e$ are the mass and charge of the electron, and h is Planck's constant. Substituting the experimental values of the constants results in satisfactory agreement with Stark's experiments being obtained. Stark's observation of the field effect on the lines of the different series of the spectrum seem also to receive simple explanation. For any element the different series correspond (on theory) to series of stationary states in which one electron moves in an orbit outside the others. The nearer $\phi_r(n)$ approaches unity the less is the disturbance due to the inner electrons and the more closely does the motion of the outer one approach to that of the H-atom electron. Now for He and Si, being elements of low atomic weight, $\phi_r(n)$ is nearly unity for the Diffuse series, but not so nearly for the Sharp series or Principal series, so that the field should have much greater effect on the first series, as Stark found. The Diffuse He series would here correspond to transition between two stationary states, one affected, the other unaffected, by the field, while for H both states would be affected. This might account for Stark's observation that the components were not (as for H) polarised relatively to the field.

In the case of a magnetic field, to obtain the connection with the ordinary mechanics and also to agree with experiment, the author's conclusion is that the field effect on the stationary states of the H-atom is simply a superposed rotation of frequency r round the axis of the field, and that the transition radiation is so changed by the field as to have the polarisation and frequencies of a Zeeman triplet. The assumption is equivalent to supposing that the energy of the H-atom in its stationary states is unaffected and that the previously assumed relation $h\gamma = \mathrm{A}_1 - \mathrm{A}_2$, where A_1 and A_2 are the energies in two successive states, is, in case of vibrations perpendicular to the magnetic field, replaced by $\mathrm{A}_1 - \mathrm{A}_2 = h(\gamma \mp r)$. A possible explanation of the complex Zeeman-effect of double lines is indicated on this basis. G. W. DE T.

1071. *Effect of Electric Field on Spectrum Lines.* **J. Stark** and **H. Kirschbaum.** (Ann. d. Physik, 43. 7. pp. 1017–1047. April 2, 1914.)—A continuation of previous work [see Abstract No. 238 (1914)]. A detailed description is given of the electrical method employed to cause the atoms of various substances to emit light in the canal rays, and particulars are given of the concave-grating apparatus used. The series lines of H, He, and Li were investigated, together with lines of Na, Mg, Ca, Al, Tl, and Hg, and the band spectra of H and N. The results are tabulated. The series laws are discussed in relation to the effect of the electric field, as are also (i) the broadening of series lines due to increased current and vapour density, and (ii) the pressure shift of spectral lines. A. W.

1072. *Origin of Spectra.* **R. J. Strutt.** (Nature, 93. p. 32, March 12, 1914.)—It has been known for some years that a stream of luminous vapour can be distilled away from the mercury arc *in vacuo*, the vapour still remaining luminous when it has passed far beyond the limits of the electric field. This luminosity is quenched when the stream passes near a negatively electrified metal surface. The author has now succeeded in extending these results to other, less volatile metals. The present paper gives a preliminary account of some of the more significant observations. In the case of sodium, under favourable conditions a very curious behaviour is observed. Where the distilled luminous vapour leaves the lamp, the light is yellow and is dominated by the D-lines. Farther on it becomes green, and the lines of the two subordinate series outshine the D-lines. Finally, farther still, the D-lines again predominate. Another interesting effect is seen when the luminous stream is made to pass through a negatively electrified wire net. As in the case of mercury, the glow is partially extinguished; but spectroscopic examination shows that the lines of the subordinate series are far more affected than the D-lines. Whatever view be taken of the origin of the distilled glow, this latter experiment shows that the systems which give rise to the subordinate series are not the same as those which give rise to the principal series. In the case of potassium, the development of the subordinate series in the distilled glow is very striking, and the existence of a series relation between the lines is visible at a glance, since the series are not confused by extraneous lines. The photography of this spectrum will be undertaken, and it is hoped this will lead to an improved knowledge of the series and their convergence point. With magnesium, the colour initially is green, dominated by the triplet *b* and the green band of the "magnesium hydride" spectrum, upon which as a background *b* lies. As the vapour moves on these die out, but the blue flame line λ4571 survives much longer. On passing the vapour through a wire gauze at — 40 volts, all the features of the spectrum which have been mentioned were found to diminish in intensity, but the effect on the blue line and on the bands of magnesium hydride was much stronger than the effect on *b*. The extinction of the band spectrum of the hydride is specially significant. Experimental details, and a discussion of the origin of the distilled glow, will be given in a subsequent paper. A. W.

1073. *The Transfer of Energy of Motion in the Excitation of Light by Canal Rays.* **W. Wien.** (Ann. d. Physik, 43. 6. pp. 955–964, March 20, 1914.)—Up to the present, experiments on the alteration of velocity in the path of canal rays have only produced negative results; no diminution of the velocity has been proved. From this it follows also that only a small transfer of kinetic energy takes place to resting gas molecules from such canal-ray atoms as are not absorbed. In the present experiments great dispersion is obtained with a grating in order to ascertain whether the spectral lines excited by canal rays show any increase in width as might be expected according to Doppler's principle and the small alteration of velocity. The results throughout are of a negative nature. The experimental details are given, and the results shown graphically. From the negative nature of the results it is concluded that with the excitation of the observed spectral lines, at least with the greatest portion of the emitted rays, the collisions are effective in which there is no considerable transfer of velocity. This is in agreement with the assumption that those collisions which bring about the recharging of the atom also cause the emission of light. A. E. G.

1074. *Dynamical System Illustrating Fluorescence.* **N. P. McCleland.** (Cambridge Phil. Soc., Proc. 17. No. 4. pp. 321–322, Jan. 30, 1914.)—The characteristic feature of the phenomenon of fluorescence is that the period of the exciting force differs from that of the induced vibration. No simple dynamical system appears to have been brought forward hitherto in which this condition is fulfilled, consequently it appeared of interest to suggest the following, which is founded on a well-known model of the atom. Suppose a particle of unit mass revolves in a circular orbit about a fixed point, there being no resistance to the motion, but that forces exist which damp vibrations along the radius vector. The law of attraction here taken is that of the inverse square, but a similar result would be obtained under any law permitting stable motion. This system is then supposed acted upon by a periodic force in its own plane, the disturbance being small. It is then shown that the system responds in such a way as to send out two trains of waves of different period, and these do not combine to give a single train of the same period as the initial disturbance. E. H. B.

1075. *Photometric Study of the Fluorescence of Iodine.* **R. W. Wood** and **W. P. Speas.** (Phil. Mag. 27. pp. 531–538, March, 1914. Phys. Zeitschr. 15. pp. 317–321, April 1, 1914.)—A continuation of previous work on the effect of admixture with other gases upon the fluorescence of iodine-vapour [see Abstracts Nos. 469, 470 (1911)]. In this investigation the effect of the iodine vapour itself at different pressures on the fluorescence is worked out. The relationship between the temperature and the intensity is first determined photometrically by viewing end-on a tube illuminated axially by the focused beam of a quartz mercury arc. The temperature is varied from — 80° to 75° and a max. intensity occurs at 20–25° C. (Temperature-Intensity Curve). Another curve showing the total fluorescence radiation of *all the molecules* is then obtained by combining these results with the pressures of the vapours at the various temperatures, and the curve exhibits a maximum at 0·2 to 0·3 mm. pressure. From these two curves it becomes possible to construct a third curve showing the decrease of intensity of a *constant number* of iodine molecules by iodine-vapour. The vapour has a measurable fluorescence at — 80° C., and the results show that the non-fluorescing molecules begin to reduce the intensity of fluorescence when the pressure rises to 0·015 mm. The intensity is reduced from 100 to 19 by these molecules at a pressure of only 0·4 mm., whereas the similarly effective pressures for other gases are H_2, 24 mm.; air, 11 mm.; CO_2, 7 mm.; ether-vapour, 3 mm.; iodine chloride, 1·8 mm.

It is probable that chlorine is still more effective than iodine in reducing the intensity on account of its electro-negative character. In the case of bromine vapour the destroying action is so powerful that it is only possible to observe fluorescence at about 0·001 mm., or — 80° C. The fluorescence spectrum is discontinuous, and some of the observed decrease in intensity, as well as the change in colour from red with the denser vapour to greenish yellow with the cooler vapour, is due to the selective absorption of the interfering molecules. This absorption is stronger at 0° than at room temperatures. No trace of purely surface fluorescence is observable.

C. S. G.

1076. *Photometry of Luminescence.* **F. v. Hauer** and **J. v. Kowalski.** (Phys. Zeitschr. 15. pp. 322–327, April 1, 1914.)—A monochromator for ultra-violet light and a spectrophotometer for dealing with weak sources of light are described. The use of these instruments for various purposes is considered. It is shown that the distribution in the momentary bands given by the phosphorescence of phenanthrene may be separated from the persistent bands. These latter only appear when the excitation falls within the region of the selective absorption of phenanthrene. The maximum of the fluorescence of Li-K-platinocyanide lies at about 390 $\mu\mu$ and decreases towards the ultra-violet end of the spectrum. Excitation of the fluorescence of Rb-platinocyanide by different sources gives different positions for the max. intensity of the fluorescence band. With light of wave-length λ4047 the max. intensity is at about 470 $\mu\mu$. The effect of temperature was considered in relation to the persistent phosphorescence bands of samarium-calcium phosphide. It was found that the max. intensity of two different phosphorescence bands occurred at nearly the same temperature—about 170°. But the temperature coefficients of the intensity are not the same for different bands, and in consequence a colour variation may be observed in the total radiation. The velocity of the decay of the phosphorescence increases in general with the temperature, though this increase is different for different bands, and hence in the decay also a variation of colour can be seen. The phenomena dealt with can be estimated quantitatively by means of the photometer to within about 6 %.

A. W.

1077. *Distribution of Scattered Röntgen Radiation.* **H. A. Wilson.** (Phil. Mag. 27. pp. 383–385, Feb., 1914.)—On the electromagnetic pulse theory of the X-ray, the author derives a formula for the distribution of the scattered Röntgen radiation round a radiator containing elements of small atomic weights. It is now well established experimentally that the intensity of the scattered radiation on the emergent side is greater than that on the incident side of the radiator, and that the distribution on the incident side is given by $I_\theta = I_{\pi/2}(1 + \cos^2\theta)$, where θ is the angle between the scattered radiation and the incident primary radiation. Recent work on the diffraction of X-rays by crystals has been explained by supposing the rays to be reflected by planes in the crystal which contain a regular periodic distribution of atoms. Metals in the solid state consist largely of small crystals arranged in an irregular manner. We may therefore suppose that the scattered radiation from a metal plate must be due partly to internal reflection from an immense number of small crystals oriented at random, and partly to scattering by the amorphous portion of the metal. On this assumption the following formula for the distribution is obtained: $I_\theta = A\,[(1 + \cos^2\theta)/\cos\tfrac{1}{2}\theta] + B\,(1 + \cos^2\theta)$, where A and B are constants and θ is the angle between the scattered radiation and the incident radiation. In this formula the first term represents scattered radiation due to crystals, and the second, that from the electrons distributed at random. When A is put equal to B, the values for I_θ obtained from the formula agree very closely with the experimental values of Crowther. In this case half the scattering electrons are in crystals, and half distributed at random. The excess of scattered radiation on the emergent side seems, therefore, to be easily explained on the theory that Röntgen rays are very short electromagnetic waves or pulses. E. A. O.

1078. *Interference of Röntgen Rays and Heat Motion.* **P. Debye.** (Ann. d. Physik, 43. 1. pp. 49–95, Dec. 31, 1913.)—The author gives various calculations relating to the theory which indicates that heat motion in the atoms has an essential influence on the interference phenomena observed with Röntgen radiation. The interference intensity decreases exponentially with respect to heat motion (*a*) with increasing angular distance between incident and observation direction, (*b*) with increasing temperature, (*c*) with decreasing wave-length. The exponent of the exponential function vanishes when $T = 0$ with failing null-point energy and maintains a finite value when a null-point energy exists. The exponent is inversely proportional to the square of the wave-length. The interference intensity is accompanied by a dissipation intensity which is most intense where the interference intensity appears most feeble, and *vice versa.* The course of the phenomenon can be calculated when data are forthcoming on the behaviour of the specific heat as function of the temperature. A law of similarity holds as with the specific heats of monatomic bodies, according to which the course of temperature is a function of the relation of the characteristic temperature to the temperature of observation. J. J. S.

1079. *Röntgen-ray Reflection.* **C. G. Darwin.** (Phil. Mag. 27. pp. 315–333, Feb., 1914.)—This is a first approximation to a mathematical theory of reflection of Röntgen rays, assumed with W. L. Bragg [Abstract No. 989 1913)] to consist in reflection from a set of parallel planes of atoms on the model of the experimental arrangement which has hitherto proved most fruitful, reflection from planes parallel to an external face of the crystal. The ordinary laws of electromagnetic theory are assumed, with a somewhat less satisfactory supplementary assumption. The observed exponential absorption of homogeneous rays is probably a statistical effect, but it is here assumed that the amplitude of a wave passing through matter diminishes exponentially with an absorption coefficient half that observed for the intensity. This gives the correct form for the absorption, and is to a certain extent experimentally justified by an experiment by Moseley and Darwin [Abstract No. 1333 (1913)]. The assumption that scattering and absorption are proportional made in the paper referred to cannot be maintained, the abbreviated proof given being unsound, and they are here taken as independent.

After discussing the lines photographed by Moseley in his method of finding the X-ray spectra of the elements, the intensity of reflection is found both for monochromatic and for heterogeneous radiation, the results being compared with Moseley and Darwin's experimental results with rock-salt. The reflection observed is, however, greater than that calculated, showing the theory to be inadequate in some particulars. The wave scattered by one atom is found to disturb the vibrations of the others. The existence of a refractive index for both crystalline and amorphous substances is indicated by the theory. The "excess radiation" observed in the scattering of X-rays at small angles by amorphous substances [Abstracts Nos. 618, 1168 (1911)] is accounted for by the theory as an effect of the several electrons in an atom. The correction for the temperature vibration is calculated.

G. W. DE T.

1080. *Spectra of Röntgen-ray Beams emitted by Antikathodes of Copper, Iron, and Gold.* **M. de Broglie.** (Comptes Rendus, 158. pp. 623-625, March 2, 1914.)—The author gives the lines in the spectra of copper, iron, and gold, photographed by a method previously described [see Abstracts Nos. 243, 244 (1914)]. The results obtained are included in the following table—

Anti-kathode.	Rays.	(α = Complement of Angle of Incidence.)	Sin α.	Remarks.
Cu......	End of intense band............	4° 9′	0·0857	—
	End of clear band...............	9 3	0·1622	—
	Ray, medium intensity.........	9 7	0·1679	—
	Ray, medium intensity.........	10 0	0·1740	—
	Ray, intense	14 3	0·2462	—
	Ray, intense	15 8	0·2728	—
Fe......	End of intense band...........	9 1	0·158	—
	End of clear band...............	15 2	0·262	Ni (?)
	Ray, broad medium intensity	16 9	0·295	Ni (?)
	Ray, medium intensity.........	18 0	0·309	—
	Ray, very intense	19 9	0·340	—
Au......	End of intense band...........	4 9	0·0850	Cu (?)
	End of clear band...............	9 5	0·165	Cu (?)
	Ray, fairly intense	11 0	0·191	A (doublet)
	Ray, fairly intense	13 0	0·226	B
	Ray, intense	14 4	0·248	C (Cu)
	Ray, very intense	15 9	0·274	D (Cu)
	Ray, feeble........................	17 2	0·295	—
	Ray, interior	22 4	0·381	Probably second order of A
	Ray, exterior	22 6	0·385	
	Ray, feeble........................	27 0	0·453	Probably second order of B

The above results for copper and iron are in good agreement with those of Moseley [Abstract No. 467 (1914)]. An antikathode of crystalline copper gave precisely the same spectrum as that of the ordinary pure specimen whose spectrum is given in the above table. In the spectrum of gold, the rays C and D are those of copper; the antikathode in this case consisted of a gold plate mounted on a copper block, and during the exposure the gold had been fused, thus exposing the copper to the rays. The iron employed contained nickel as an impurity. The spectra were obtained by reflection from a cubic face of a rock-salt crystal. [*Erratum*, ibid. p. 907, March 23, 1914.]

E. A. O.

HEAT.

1081. *Expansion of Mercury and Silica.* **F. J. Harlow.** (Phys. Soc., Proc. 26. pp. 85–94; Discussion, 94–96, Feb., 1914.)—A cylindrical, and also a spherical, bulb of fused silica was fitted with mercury and used as a weight thermometer over the range 0° to 300° C. The results for the two shapes did not differ by more than 1 in 18,000, so that at least as regards these fused silica vessels the longitudinal and radial coefficients of expansion may be considered identical. The bath liquid was paraffin for low, and thick oil for high temperatures. The results for the apparent expansion of mercury in silica are given in a table. Next, Callendar's values for the expansion of silica are used to deduce from the above the absolute expansion of mercury. These results for the range 0° to 100° agree to 10 in 18,000 with those found by Chappuis; whereas they disagree by as much as 70 in 18,000 (for some parts of the range) with those found by Callendar and Moss by the absolute method. In the *discussion*, **F. E. Smith** considered that the films adhering to glass and silica might cause the great discrepancy mentioned above. If so, all weight-thermometer methods would be suspect. **J. E. Sears** mentioned an empirical equation which Donaldson had obtained to fit the experimental result for mercury. He now produced a quartic which was calculated on the mean best results for silica applied to Harlow's results for the apparent coefficient of mercury. P. E. S.

1082. *Thermal and Electrical Conductivity of Copper between 20° and 373° absolute.* **W. Meissner.** (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 262–272, March 15, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—The law of Wiedemann-Franz and Lorenz that for all pure metals $\lambda/\kappa T$ is an absolute constant (λ = thermal and κ = electric conductivity, T = abs. temp.) was well established between 0° and 100° C. by the experiments of Jaeger and Diesselhorst although small divergences appeared with the different metals, and a simple theoretical explanation was given on the Drude electron theory of electrical and thermal conduction. Nernst's work on the specific heats of metals at low temperatures has shown this law to be quite untenable in its original form. While Jaeger and Diesselhorst's experiments indicated that λ was almost independent of the temperature, Lees has shown that at temperatures between 18° and —170° C., λ increased in the case of some metals up to 20%. In order to obtain data on the temperature dependence of λ, and on the validity or not of Lorenz's law, experiments were undertaken with the same piece of metal down to the temperature of liquid hydrogen. The electric heating method of Kohlrausch as modified by Diesselhorst was employed, whereby the ratio of λ to κ is directly obtained as also the value of κ. Experimental details illustrated by diagrams are given. The measurements between 0° and 100° C. were made in baths of ice, petroleum, and paraffin oil, while those at lower temperatures were carried out with liquid oxygen and hydrogen. A graphical presentation of the results is given. The value of $\lambda/\kappa T$ was found to be in agreement with Lorenz's law and the experiments of Jaeger and Diesselhorst between 0° and 100°, *i.e.* a constant, but it slowly decreases with falling temperature and more rapidly at very low temperatures until at 20° abs. it has only a seventh part of the value at 0° C. A similar behaviour is seen with the thermal resistance $1/\lambda$, which is practically constant between 0° and 100° C., but rapidly diminishes at very low temperatures, possessing at 20° abs. only a fourth the value which it has at 0° C. The general conclusion drawn is that neither Lorenz's law nor the assumption of a constant thermal conductivity of metals have any universal validity at low temperatures. H. H. Ho.

1083. *Variation with Temperature of the Specific Heat of Sodium in the Solid and the Liquid State; also a Determination of its Latent Heat of Fusion.* **E. Griffiths.** (Roy. Soc., Proc. Ser. A. 89. pp. 561–574, March 2, 1914.)—Using the method described previously [see Abstract No. 1841 (1913)], the author has determined the specific heat of sodium in the solid and liquid state. The range of temperature in each determination was approximately 1·5°, which made it possible to determine the specific heat close to the melting-point; in fact, determinations were made with the middle point of the range only 2° below the melting-point. The sodium was enclosed in a sheath of copper of special form.

The specific heat values in the solid state depend on the nature of the previous heat-treatment of the sodium; definite, reproducible values could only be obtained when the metal was annealed by slow cooling from the liquid state. Between 0° and 95·58° the specific heat of the solid increases from 0·2829 to 0·3258, the temperature coefficient varying continuously, whilst between 100·81° and 138·47° the specific heat of the liquid decreases fairly regularly from 0·3284 to 0·3189. The freezing-point of sodium, as determined by the cooling curve method, was found to be 97·61°. From time-temperature observations in the solid and liquid states, during the supply of heat at a constant rate, the latent heat of fusion of sodium was found to be 27·52 gm.-cals. Sodium in the quenched state is less dense than in the annealed state, the difference being of the order of 1 part in 7000. T. S. P.

1084. *Investigations of Specific Heats at Low Temperatures.* VIII. **W. Nernst** and **F. Schwers.** (Preuss. Akad. Wiss. Berlin, Ber. 10. pp. 355–370, 1914.)—The authors have further developed the method for the determination of specific heats at low temperatures with the vacuum calorimeter [see Abstract No. 1702 (1911)], and give full particulars of the various improvements. Details of the results obtained, at temperatures varying between 19·1° abs. and 96·5° abs., for the following substances are given: Al, Tl, carborundum, calcium oxide, calcium hydroxide, calcspar, silver chloride, silver iodide, potassium aluminium sulphate, Mg, Si, lead oxide, and lead iodide. The T^3-law of Debye holds at these low temperatures for Al, carborundum, and Si. T. S. P.

1085. *Transition Temperatures of the Hydrates of Sodium Carbonate as Fixed Points in Thermometry.* **T. W. Richards** and **A. H. Fiske.** (Amer. Chem. Soc., Journ. 36. pp. 485–490, March, 1914.)—In continuation of previous work [see Abstract No. 1178 (1911)] the authors have determined the transition-point of sodium carbonate decahydrate to the heptahydrate, and found it to be 32·017° on the hydrogen scale (32·121° on the mercury thermometer). The other hydrates have also been analysed, and the statements of other investigators confirmed. It is shown, however, that all the hydrates lose water easily at ordinary temperatures into air dried by concentrated sulphuric acid, leaving the salt essentially anhydrous. A. F.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1086. *Electron Theory of Metallic Conduction.* **W. F. G. Swann.** (Phil. Mag. 27. pp. 441-454, March, 1914.)—Drude obtains the relation $\sigma = ne^2\lambda v/4\alpha\theta$, where σ is the electric conductivity, n the number of electrons per c.cm., λ the mean free path, and $\alpha\theta$ is the kinetic energy of a gas molecule at a temperature θ. It is obtained on the assumptions that in the absence of an electric field all the electrons move with the same velocity, and that the velocity arising from a field is the velocity produced while travelling between two points of collision, the essential assumption being that at each collision the effect of all previous actions of the field on the electron are wiped out. The author shows that Drude's calculation is vitiated by some purely mathematical errors, and that the correction of these leads to the formula $\sigma = ne^2\lambda v/3\alpha\theta$. Drude's formula, however, and not the correct deduction from his assumptions, is in agreement with experiment. Now the only practicable combination of the physical qualities involved which is of the dimensions of electric conductivity is that of these formulæ, so that the numerical factor is the only part which depends on the correctness of the theory on which it is founded. The conclusion is therefore that the assumptions are nothing like as representative of the facts, as has been supposed, even in the matter of the relation between the thermal and electrical conductivity, a question to which a special investigation is devoted. Riecke, in 1898, before the publication of Drude's result, had obtained a formula which, when interpreted in terms of the modern electron theory, agrees with that here obtained from the same assumptions [see Abstracts Nos. 299, 1024 (1899)]. Drude's error has also been pointed out recently by Bohr. G. W. DE T.

1087. *Mean Energy of a Rotating Electric Molecule in a Radiation Field.* **A. D. Fokker.** (Ann. d. Physik, 43. 5. pp. 810-820, March 13, 1914.)—Eucken [see Abstract No. 517 (1912)] observed that for hydrogen the curve for specific heat approaches the specific heat axis asymptotically at the absolute zero. Attempts to explain these results of Eucken's have already been made by Einstein and Stern and by Ehrenfest [see Abstracts Nos. 1016, 1445 (1913)]. A molecular agitation at the absolute zero was assumed by the former, but not by the latter. In the present paper an attempt is made on different lines to explain the hydrogen results. This is based on Einstein's theory of the specific heat of rigid bodies. In that theory a rigid body is subjected to oscillations of definite frequency in consequence of its elasticity: heat energy is considered to be the energy of these oscillations. If the oscillating systems are supposed to be charged the heat capacity is unaltered, but these oscillators can then be considered to be in energy equilibrium with black radiation, and hence each has the mean energy of a Planck resonator of the same frequency. Hence assuming Planck's radiation formula to be correct, the amount of energy in each oscillating system is known, and thus also the specific heat. This method is applied to hydrogen, where the oscillating systems are taken to be the molecules, which are considered charged. It leads to the result that the specific heat curve would have a tangent which is vertical at the absolute zero, whilst Eucken's results showed a horizontal tangent. J. R.

1088. *The Electromagnetic Field of Force.* **T. Gross.** (Zeitschr. Vereines Deutsch. Ing. 57. pp. 1952–1954, Dec. 6, 1913.)—An abstract of a series of researches by the late T. Gross, to be published by the Verein Deutscher Ingenieure. They constitute a revision of magnetic theory. Among the conclusions reached are the following. The magnetic field of a steady current has magnetic forces only along its lines of force, not between these; any forces between these are not magnetic. The repulsion between a diamagnet and a magnet depends on the diamagnet, and is independent of the polarity of the magnet; it cannot depend on the magnet. Diamagnetism therefore differs in its nature from magnetism. The action between a magnet and a diamagnet is at right angles to the axis of the former and to its lines of force. Bodies tend so to place themselves in a magnetic field that their magnetic resistance shall be a minimum. Diamagnetic fields have to be recognised as well as magnetic. In a diamagnetic field an iron bar places itself equatorially, like a bar of bismuth in a magnetic field. Bismuth places itself axially in a diamagnetic field, like iron in a magnetic field. The diamagnetic field repels iron, attracts bismuth. Cu, Ag, Au act as magnets in a magnetic, as diamagnets in a diamagnetic field; such substances are "amphibolous." These substances present peculiar phenomena when in the form of a ring. In very weak fields they act as weakly magnetisable substances. In the form of spheres they are attracted in a magnetic, repelled in a diamagnetic field. There is a diamagnetic induction as well as a magnetic induction by a steady current. By diamagnetic self-induction currents can be induced on magnets. The induced diamagnetic lines lie in the same plane as the induced current and the axis of the magnet. In the field of an alternating current amphibolous bodies and closed induced current coils of small size rotate continuously so as to bring points opposed on the axis of the field to lie equatorially; but they do not rotate if symmetrical with regard to the axis or the equator. Bodies distinctly paramagnetic or diamagnetic do not rotate. In an electromagnetic field we have to distinguish between magnetic forces, diamagnetic forces, and induction. The first two of these are ponderomotive; the last acts only as a resistance. The repulsion of a secondary coil is a diamagnetic phenomenon, the secondary coil being an electrodiamagnet. We have to distinguish between electromagnetic or electrodiamagnetic phenomena in a field of force and electrodynamic phenomena between two fields of force, independent of one another. With alternating inducing currents, on the other hand, there is no continuing electrodynamic action unless the two have a common magnetic field. The alternating current can induce magnetisation, but the magnet pole induced attracts either pole of an ordinary electromagnet or magnet. Ponderomotive electrodynamic forces exist always between steady currents, never between steady and alternating, and between two alternatings only when one of these is induced in the field of force of the other. An alternating and a steady current along the same wire act electrodynamically with regard to a third as two independent currents. Two currents, i_1, i_2, along the same wire, acting electrodynamically upon one another; the energy of either, for unit resistance, is $i^2 + i_1i_2$ or $i_2 + i_1i_2$, the energy of either alone *plus* the electrodynamic energy between them. If they do not act electrodynamically on each other, the energy of either is i_1^2 or i_2^2 simply, as if i_1 or i_2 had been alone.

Rotatory apparatus of a new kind is described; a coil bearing an alternating current, placed with its axis at right angles to a steady magnetic field, rotates; so does a coil carrying a steady current similarly placed in an alternating magnetic field. The steady current is a progressive, the alternating current a stationary wave, whose components are the electric, the magnetic, and the diamagnetic oscillation ; of which the last is called the "current." The fundamental law is that similarly vibrating, similarly directioned oscillations repel one another ; those vibrating in opposite directions attract one another. Paramagnetic bodies absorb the magnetic lines of force more powerfully than air does, and become magnetic ; non-conductors absorb the electric lines more powerfully than air does, and become electrically charged. Currents were obtained in open circuits. By means of an alternating current permanent magnets were obtained which had no opposed poles, but whose attraction and repulsion of a suspended magnet-needle depended much more upon the relation of their axis to the plane of oscillation of the magnet-needle. A. D.

1089. *Accelerated Conductors.* **R. C. Tolman, E. W. Osgerby,** and **T. D. Stewart.** (Amer. Chem. Soc., Journ. 36. pp. 466–485, March, 1914.) —The force of gravity has been found to produce a difference in electrical potential between the two ends of a vertical tube of salt solution. This difference in potential evidently arises from the unequal weights of the positive and negative carriers of electricity in the solution. Thus the lower end of a tube of potassium iodide solution becomes negatively charged, since the negative iodide ions are heavier than the positive potassium ions. In a similar way we should expect a tube of solution, when subjected to acceleration, to show a difference in potential between the two ends. For example, the rear end of a tube of potassium iodide solution should show a negative charge so long as the tube is being accelerated.

The apparatus used by the authors for accelerating electrolytes consisted essentially of a glass tube provided with electrodes and bent to fit the rim of an ordinary bicycle wheel. The tube was filled with electrolyte, the wheel given a sudden acceleration, and the current noted which flowed through a galvanometer placed in the external circuit. Sodium iodide and lithium iodide solutions were tried, and the observations gave conclusive proof that potential differences are developed at the ends of a column of accelerated electrolyte. Experiments were also tried with metallic conductors, and showed that the mass of the carriers in metals is probably less than one two-hundredth of that of the hydrogen atom. E. H. B.

1090. *Nuclear Electrons.* **A. van den Broek.** (Phil. Mag. 27. pp. 455–457, March, 1914.)—Shows that Rutherford's theory and the experimental data both agree in giving for the intra-atomic charge, not half the atomic weight, but the number M which each element occupies in Mendelejeff's series arranged in order of increasing atomic weight. E. H. B.

1091. *Quantum Theory and Rational Units.* **G. N. Lewis** and **E. Q. Adams.** (Phys. Rev. 3. Ser. 2. pp. 92–102, Feb., 1914.)—A discussion of the numerical relations between the electron charge, the Wirkungs-quantum, and the constant of Stefan's law. An endeavour is also made to found a rational system of units. E. H. B.

1092. *Some Questions Relative to the Lorentz Transformation in Electrodynamics.* **R. Marcolongo.** (Accad. Lincei, Atti, 22. pp. 402–408, Nov. 9, 1913.)

1093. *The Problem of Two Spherical Conductors.* **G. R. Dean.** (Phys. Rev. 1. Ser. 2. pp. 316–320, April, 1913.)—Mathematical.

1094. *Fall of Electrical Potential in the Free Air up to 9000 m.* **E. Everling.** (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 240–244, March 15, 1914.)—Previous investigators have shown by means of observations made from a free balloon, that the fall of potential diminishes with increasing height from about 100 volts/m. at ground-level to about 25 volts/m. at 1500 m.; about 10 volts/m. at 4000 m.; and about 8 volts/m. at 6000 m. height. Measurements from a free balloon are given according to which the rate of fall diminishes with increasing height in a logarithmic manner. There is some doubt about the absolute values of the gradient at different heights, with reference to which further experiments are in progress, but from a comparison with previous ascents made in similar anticyclonic weather, it appears that the gradient at 9000 m. is about 3·5 volts/m. R. C.

1095. *Atmospheric Electric Potential Results at Edinburgh during* 1912. **G. A. Carse** and **G. Shearer.** (Roy. Soc. Edinburgh, Proc. 33. pp. 317–332, 1912–13.)—The results of some previous intermittent observations on atmospheric electricity have already been brought forward in an earlier paper [see Abstract No. 1304 (1910)]. The present series was nearly continuous during 1912, and refers to potential gradient only. Autographic records were obtained from a water-dropper of the well-known Kelvin type to which was attached an apparatus which earthed the water tank for 5 minutes at the end of every hour. This provided a series of time marks and also indicated the zero line. Absolute observations were made with a Wilson universal electrometer which measures the charge induced by the earth's field on a horizontal plate. A flame collector was also sometimes used. Frequent eye readings on one or two days gave curves in very close agreement with the autographic records, but the latter showed a slightly greater lag, as would be expected from the greater electrical capacity of the instrument. For hourly values the curves were tabulated by measuring the area cut off between consecutive hour marks and so deducing the mean potential for the hour. The annual range shows a well-marked maximum in Jan. and a minimum during the summer. This is in agreement with the type of annual variation found at other stations. Mean daily curves are given for each month and for the summer and winter halves of the year. An early morning minimum at about 4 a.m. is noticeable on all the curves. Harmonic analysis of the daily variation shows that the amplitude (a_1) of the 24-hour term is greater than that of the 12-hour term (a_2) during the winter months and less in the summer. The value of a_1 varies from 8 volts/m. in Sept. to 71 in Jan. The variations in the phase of the 24-hour term follow the time of sunrise. The mean gradient at Edinburgh throughout the year was 167 volts/m., somewhat greater than the average for continental stations. J. S. Di.

1096. *Measurements of Electrical Conductivity in the Free Air up to a Height of 9000 m.* **A. Wigand.** (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 232–239, March 15, 1914.)—The method of observing is to carry a Gerdien apparatus [see Abstract No. 2078 (1905)] or a modification of it on a manned balloon and to make observations of λ_+ and λ_- at frequent intervals. The results of four separate ascents are given, the max. heights attained in which were respectively 5400 m., 6800 m., 8510 m., and 9005 m. The total conductivity λ ($=\lambda_+ + \lambda_-$), for each ascent increases with increasing height at an increasing rate.

At the surface λ is of the order of 10^{-4} e.s. unit; at 1000 m. it varies from 10^{-4} to 4×10^{-4} for the different ascents; at 5000 m. it varies from 11×10^{-4} to

17×10^{-4}, while the values at 7000, 8000, and 8880 m. for the single ascent for which the results are plotted are 18×10^{-4}, 25×10^{-4}, and 37×10^{-4} e.s. unit.

The explanation of the increase is ascribed partly to the diminished pressure of the air which induces an increased mobility of the ions, and partly to an increase in the number of ions aloft. The shape of the curve for change of intensity of ultra-violet radiation with height is similar to that for electrical conductivity. R. C.

1097. *Note on a Theory of Thunderstorms.* **H. Nagaoka.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 228–231, Feb., 1914.)—It is considered that the phenomenon of repeated discharges can be accounted for from the standpoint that the thunderclouds form a composite dielectric. The dielectric contains clouds, ions, and air, and the charges are embedded in it. The charges accumulate, the electric field increases in strength, and the wandering of the ions and distribution of cloud particles become favourable for causing a discharge through the intervening layer. Such a composite dielectric will exhibit electric absorption and residual discharge. Further, the disruptive discharge is the cause of fresh production of ions. The sudden change of pressure in the path of the discharge will sometimes be quite favourable to the condensation of water particles on electrified nuclei. The phenomenon of repeated discharges is, on this account, a natural consequence of electric absorption in cloud masses. [See Abstract No. 1078 1909).] G. E. A.

DISCHARGE AND OSCILLATIONS.

1098. *Recombination of Gaseous Ions.* **G. Rümelin.** (Ann. d. Physik, 43. 6. pp. 821–857, March 20, 1914.)—A method of measuring the rate of recombination of gaseous ions is described which has the following advantages: Small quantities of gas only are needed since the gas remains at rest; the recombination is allowed to go on freely in the gas without disturbance by an electric field; and, further, the rate of recombination is determined at various small intervals after the production of the ions which, however, goes on continuously. The procedure is as follows. Dry dust-free gas contained in an enclosed cylindrical condenser is ionised continuously by the α- or β- + γ-rays of either Ra or Ur. Recombination is allowed to go on undisturbed for a short time, at the end of which the ions are swept out by a strong field applied for another short period. This procedure is repeated continuously by means of rotating contacts, the resulting ionisation current being measured by means of a suitable electrometer. By altering the speed of the rotating contacts the length of time during which the recombination goes on, and therefore the ionisation current, can be varied. The curve obtained by plotting the ratio of the ionisation current to the saturation current against the speed of the rotating contacts departs somewhat, especially in the case of ionisation by α-rays, from that obtained from theory on the assumption that the rate of recombination is constant. The direction of the departure is such as to indicate that recombination takes place at a greater rate immediately after the ions are produced than subsequently. This observation agrees with the view given by Bragg and others that there exists a greater tendency for two ions just formed from a molecule to recombine to form that molecule than exists between the ions at random subsequently. By taking this "initial recombination" into consideration a theoretical curve is obtained which agrees much more closely with the experimental curve, particularly for the slower speeds of rotation of the contacts. Views other than Bragg's which would account for the departure of the experimental curve from the theoretical are also discussed. The effect of the alteration of gas pressure upon the coefficient of recombination is also investigated. The coefficient decreases with decrease of pressure; the observations of Langevin and others are thus qualitatively confirmed. F. J. H.

1099. *Discharge in a Magnetic Field.* **R. F. Earhart.** (Phys. Rev. 3. Ser. 2. pp. 103–114, Feb., 1914.)—After giving a brief review of previous work in this direction, the author proceeds to describe experiments made with a view to obtaining quantitative measurements of the effect of a uniform longitudinal magnetic field upon a luminous discharge taking place between the central portions of a parallel plate condenser. With such an arrangement the conditions are somewhat simplified. A series of characteristic curves are given for air, H, and CO_2 at various pressures above and below the critical, and for various values of the magnetic field ranging from 0 to 10,000 c.g.s. units. The results indicate that at pressures below the critical pressure a weak field increases the current obtained for a given p.d., while a strong field reduces it. The lower the gas pressure the greater must be the critical value of the magnetic field to secure a reduction of current. At pressures close to the critical the effects of magnetisation are small, but above the critical pressure the longitudinal field reduces the current. The results of the paper are considered in their relation to the explanations of Strutt's experiment given by Townsend and Horton [Abstracts Nos. 582 and 583 (1914)]. F. J. H.

1100. *Long-wave Limits of the Normal Photoelectric Effect.* **A. L. Hughes.** (Phil. Mag. 27. pp. 473–475, March, 1914.)—Pohl and Pringsheim recently discussed the present position of certain questions in photo-electricity and concluded that there was not sufficient evidence to determine the relation between the max. emission velocity of photo-electrons and the frequency of light [see Abstract No. 719 (1914)]. Two laws have been proposed for the relation between the velocity and the frequency, the first being that the velocity squared, or the energy, of the photo-electron is proportional to the frequency; the second is that the velocity is directly proportional to the frequency. On account of the small ranges of wave-lengths available it is difficult to decide which is the correct relation, but it is suggested that the investigations of Richardson and Compton, as well as those of the author undoubtedly show that the results are well expressed by the first law but not by the second. Pohl and Pringsheim, in support of their contention, refer to the experiments by Kunz and Cornelius, who conclude that their results are better expressed by the second law. The experimental arrangements of Kunz and Cornelius are open to considerable objections, and it appears that, notwithstanding the objections raised by Pohl and Pringsheim, which are briefly discussed, the balance of opinion is in favour of the first law. A. E. G.

1101. *Kathode Disintegration in a Vacuum Tube.* **A. M. Tyndall** and **H. G. Hughes.** (Phil. Mag. 27. pp. 415–427, March, 1914.)—In the present experiments the following factors are dealt with:—The duration of the discharge; the previous history of the kathode; the pressure and nature of the gas; the current density; and the kathode-fall of potential. The amount of disintegration is measured in all cases by the loss of weight of the kathode. During discharge it is found necessary in general to control and measure pressure, current, and kathode-fall. A diagram of the experimental arrangements is given. As the result of these experiments the following general conclusions are arrived at. Provided that a constant kathode-fall is maintained: (*a*) Considerable changes of pressure have no influence on the amount of disintegration for a given current and duration of discharge; (*b*) new and old kathodes of the same area disintegrate practically to the same extent under the same conditions of current and duration of discharge; (*c*) the rate of disintegration for a given current density is constant throughout discharge. Thus it is not affected by the removal of gases from the surface of the kathode by previous discharges. The influence of the kathode fall of potential on the rate of disintegration has been investigated at low values of kathode-fall. No simple relationship (such as exists at high values) has been observed. The rate of disintegration appears to vanish at the normal kathode-fall. The linear relationship which exists between current densities and high kathode-falls does not hold in the general case. Preliminary work on the influence of the nature of the gas shows that at low values of kathode-fall there is no appreciable difference between rates of disintegration in hydrogen and air under similar conditions. Certain theoretical considerations are advanced in connection with some of the above results.

A. E. G.

1102. *Attempts to Observe the Production of Neon or Helium by Electric Discharge.* **R. J. Strutt.** (Roy. Soc., Proc. Ser. A. 89. pp. 499–506, Feb. 2, 1914.)—An endeavour was made to repeat the experiments of Collie and Patterson, the method used being one in which hydrogen could be removed and the test for neon carried out without pumping the gas out of the apparatus or manipulating it over a pneumatic trough in any way. It is extremely difficult to avoid in the latter processes the entrance of minute air-bubbles entangled between mercury and glass. In the experiments the neon contained in 1/100 c.cm. or even 1/1000 c.cm. of air could be detected. The results obtained were negative, and no trace of Ne or He could be obtained by spectroscopic observations.

J. J. S.

1103. *Discharge from Liquid Points, and a Method of Measuring the Electric Intensity at their Surfaces.* **J. Zeleny.** (Phys. Rev. 3. Ser. 2. pp. 69–91, Feb., 1914.)—Hitherto the discharge from pointed conductors has been studied only from points made of metal. The assumption is generally made that the phenomena of the discharge are independent of the metal of which the point is made, yet there are some facts which show that some importance attaches to surface conditions. Hence it is advisable to extend the study to materials which differ radically from metals. The author describes a method for examining the discharge from a small liquid hemispherical drop, protruding from a capillary tube, on to a plane electrode below it. The same apparatus serves for determining the surface tension of the liquid from measurements of the drop, and also for measuring the electric intensity at the surface of the point. This intensity is determined as follows. When the drop is charged the electric force acting at the surface tends to pull it outwards. The meniscus may be made to return to its position before charging by decreasing the hydrostatic pressure inside the drop. The decrease in hydrostatic pressure is equal to the electrostatic pressure due to charging, hence by measuring the former the electric intensity at the surface may be found. The liquid used in the work described is water slightly acidulated, and the radii of the drops vary from $r = 0{\cdot}0146$ to $0{\cdot}0548$ cm. It is found that the positive discharge from the point begins with a momentary current, repeated only by increasing the potential of the point. At higher potentials the current is intermittent, the luminosity of the discharge starts from a small area on the surface, and extends half-way to the plane electrode, and the meniscus is agitated. At still higher potentials the current is steady, luminosity covers the whole surface, and is confined to it, while the liquid meniscus is quiescent. The negative discharge is always in the form of a brush discharge, current almost always intermittent, and meniscus in motion, while the luminosity starts from a small area and extends out a distance of the order of the diameter of the point. The relation $f\sqrt{r} =$ constant is found, where f is electric intensity at the discharging surface when the current just ceases to flow, and r is the radius at the point. The electric forces under these conditions as well as the potentials at which the currents cease, are the same for both negative and positive discharges. These intensities are considerably smaller than those obtained by Chattock with Pt-points, and somewhat smaller than those calculated by the author, from measurements on brass points [see Abstracts Nos. 118 (1908) and 1481 (1910)]. For small points the electric intensity does not vary much with the current, for larger points the values increase to a maximum as the current is increased.

The action of β- and γ-rays is to lower the starting potential of the discharge slightly. Discussion of the results is postponed until a later paper. T. H.

1104. *On the Question of the Oscillatory Discharge of a Condenser.* **V. Smirnoff and A. Fridmann.** (Russian Physico-Chemical Soc., Journ. 45. pp. 276-282 [Physical Part], 1913. In Russian.)—Designating by V the difference of potential, and C, L, and R possessing their usual significations, the following equation holds:—

$$\frac{d^2V}{dt^2} + \frac{R}{L}\frac{dV}{dt} + \frac{1}{LC}V = 0.$$

The author quotes from the work of Fuchs, N. A. Boulgakov, and D. A. Roschansky. An expression is found for V_1 which is shown to be dependent in part upon α, β, and γ, where

$$\alpha = -\frac{r}{aL}, \quad \beta = -\frac{R}{aL}, \quad \gamma = \frac{1}{LCa^2}.$$

E. O. W.

1105. *Production of Electric Oscillations by the Arc.* **J. Zenneck.** (Ann. d. Physik, 43. 4. pp. 481–524, Feb. 27, 1914.)—The period during which the oscillations generated by the arc method are rising to their full amplitude is investigated theoretically and experimentally. The ordinary experimental arrangement is employed. In the developing of the theory the change in the amplitude from period to period only is considered, and this brings the energy equation of the oscillation circuit into a form which admits of easy integration, even for very complicated characteristics. The effects produced when the static characteristic holds are first investigated theoretically, and this leads to the Duddell conditions for oscillations. The change in the phenomena due to the dynamic characteristic is then considered, and Braun-tube photograms of the dynamic characteristics are given and explained. Photograms of the corresponding static characteristics are also

given. Braun-tube oscillograms of the rise of the oscillations are then given showing how the theoretical considerations are borne out. It is pointed out that after the oscillations of the second kind are established the resistance of the condenser circuit may be raised considerably above the critical value of this resistance for the initial conditions without destroying the oscillations.
T. P. B.

1106. *Vibrations of Lecher System with Lecher Oscillator.* III. **F. C. Blake** and **C. Sheard.** (Phys. Rev. 8. Ser. 2. pp. 217–231, March, 1914.—Paper read before the Amer. Physical Soc., Dec., 1912, and before the Ohio Acad. of Sci., Oberlin, Nov., 1913.)—It was previously found that when the Lecher system was in exact tune with the oscillator and receiver circuits, Abraham's theory ought to apply, provided the harmonics were damped out proportionally. The authors then proposed to test this point, and in this paper give some of the results obtained by working in this direction. They conclude that three conditions need to be fulfilled if the various tones are to be strictly harmonic, viz., (1) the distance between the Lecher wires must approach zero ; (2) the end capacity must approach zero ; and (3) the coupling must be loose at both ends of the Lecher system. [See Abstract No. 1572 (1912).]
E. H. B.

1107. *Calculation of the Free Period of a Single-layer Coil.* **W. Lenz.** (Ann. d. Physik, 43. 5. pp. 749–797, March 18, 1914.)—Drude, in a paper on the Tesla transformer [see Abstract 1906 (1902)], calculated the free period of a coil and measured it experimentally in a number of cases. His experimental results showed that the fundamental wave-length is of the same order of magnitude as the total length of wire used, and that it depends only slightly on the distance apart of the separate windings. His theoretical treatment was only a rough approximation, as he considered the capacity concentrated at the ends of the coil. In the present paper the capacity is considered to be distributed throughout the whole length of the coil, and a much more probable approach to facts is thus obtained. The problem is difficult, but it is shown that the coil may be considered as a cylinder with the turns fused together. The paper is divided into three parts : (1) a discussion of short coils for which the length is small compared with the radius ; (2) a discussion of long coils ; and (3) a comparison of theory with experiment. The general results are that for short coils the wave-length of the fundamental oscillation is large compared with the total length of wire, and *vice versa* for long coils. The overtones differ much from the harmonic series. For short coils the overtones lie farther apart than the harmonics, and for long coils nearer together. The formulae given for the fundamental and overtones of a long coil are very complicated, but for a short coil the wave-lengths of the fundamental and first overtone are

$$\lambda_1 = \sqrt{\frac{\epsilon_i + \epsilon_a}{2}}\ \frac{\pi}{2} \cdot L \cdot \sqrt{2\log\frac{16R}{l} - \frac{7}{2}}\,; \quad \lambda_2 = 0{\cdot}832\ \frac{\pi}{2} \cdot L \cdot \sqrt{\frac{\epsilon_i + \epsilon_a}{2}},$$

where $2l$ is the length of the coil, L the total length of wire, R is the radius of the coil, and ϵ_i and ϵ_a are the specific inductive capacities of the core and exterior of the coil. These expressions are simplified if $\epsilon_i = \epsilon_a = 1$, the value for air.

In addition to Drude's experimental results, some measurements were made by R. Lindemann to test the theory. There are discrepancies of from

10 to 20 % between calculated and observed wave-lengths, the least disagreement being for short coils ($l/R < \cdot 1$) where the windings are far apart. A very close agreement is found when the ratios of the wave-length of the first overtone and the fundamental are plotted against R/l. J. R.

1108. *Phenomena in Oscillation Circuits.* II. **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 220–227, March 15, 1914.)—This second article of the series deals with the instantaneous values of the variables in two coupled circuits with small damping and medium coupling. [See Abstracts Nos. 668 (1913) and 782 (1914).] E. H. B.

1109. *Some Instruments for High-frequency Currents and Voltages.* **W. H. Eccles.** (Electrician, 72. pp. 1044–1045, March 27, 1914.)—A description of a simple hot-wire ammeter of quick period, a very sensitive electrometer of simple construction and a convection galvanometer. All have been employed successfully by the author for high-frequency work. T. P. B.

1110. *The Propagation of Electromagnetic Waves in Wireless Telegraphy.* **G. R. Dean.** (Electrician, 73. pp. 13–17, April 10, 1914.)—A mathematical treatment of the simple Hertz element and the electric doublet.

L. H. W.

1111. *Electric Emissivity of Matter.* **J. A. Harker.** (Engineering, 97. pp. 290–291, Feb. 27, 1914. Lectures delivered at the Royal Inst.)—[See Abstract No. 1713 (1913).]

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1112. *Properties of Selenium.* **G. W. White.** (Phil. Mag. 29. pp. 370–382, Feb., 1914.)—When a selenium block is illuminated the resistance-change in the direction of the light is appreciable even with thick blocks. This fact was utilised to prepare a Se block, the conductivity of which could be measured (*a*) in a direction parallel to the illuminated face ("bridge" of the first type), and (*b*) in a direction perpendicular to this face ("bridge" of second type). The resistance-change on illuminating a Se block is always greater when used in a bridge of the second type. The change in conductivity throughout a thin layer at the illuminated surface of a homogeneous block is insufficient to explain this phenomenon. The effect of light on Se blocks, the effect of filing the surfaces, and the dependence of the resistance on the nature and pressure of the electrodes, on the voltage and on certain other conditions, all point to the existence of a high resistance at the contact of the selenium and the electrodes. The action of light on all selenium bridges is to a large extent, but not wholly, to effect a change of resistance at the electrode contact. Films of Se can be obtained by "kathode disintegration." If the deposit is received on a plate at a suitable temperature the films are continuous and light-sensitive. J. J. S.

1113. *Physical Properties of Selenium.* **P. J. Nicholson.** (Phys. Rev. 3. Ser. 2. pp. 1–24, Jan., 1914. Phys. Zeitschr. 14. pp. 1210–1213, Dec. 1, 1913. Abstract.)—Experiments were undertaken with the object of obtaining data that would help in solving the problem of the cause of the behaviour of selenium when exposed to light, and first the production of good films of Se in various forms was attempted. Considerable information was collected regarding the sputtering of Se kathodes, and an improved form of sputtering apparatus was made use of. Many semi-transparent films of amorphous Se were transformed into the metallic state. The ultra-violet absorption of metallic Se was roughly determined. Selenium cells have been found to retain a large sensibility down to 280 $\mu\mu$, and the sensibility curve for short wave-lengths was determined. Sensibility curves were obtained when exposure was limited and of varied duration as well as when a steady state was reached. The law $d = \mathrm{DI}^{\beta}$ was found to hold with considerable accuracy, where $d =$ change in conductivity, $\mathrm{I} =$ energy of incident beam, and β and D are constants. When exposure is between 12·5 secs. and 20 secs. Pfund's results are confirmed that $\beta = 1$ in red and infra-red, but $\beta = \frac{1}{2}$ for shorter wave-lengths. For unlimited exposures $\beta = \frac{1}{2}$ throughout the spectrum. The law $d = \mathrm{DI}^{\beta}$ was found to hold with considerable accuracy when the exciting source was Röntgen rays; β being 1 for short exposures and $\frac{1}{2}$ when time of exposure is unlimited. A mathematical deduction has been made, with the electron theory as a basis, from which the most important facts known regarding the behaviour of Se cells follow, *e.g.*:—(1) Variation of change in conductivity with square root of intensity for long exposures. (2) Variation of change in conductivity directly with the intensity when time of illumination is short compared with that required to reach a steady state. (3) High sensibility of cells of high resistance. (4) Decrease of inertia with increasing intensity of illumination, absorption coefficient, and "dark conductivity." This also explains variation of sensibility with temperature and other disturbing factors. (5) Dependence of rate of recovery upon the same causes. (6) Change in sensibility when cell is illuminated continuously with a beam of light for whose constituents k, the coefficient of absorption, is nearly constant. (7) Decrease in inertia when this beam is red, or infra-red. (8) Possible explanation of "light-negative" selenium and anomalous effects. J. J. S.

1114. *Base Metal Thermo-couples.* **O. L. Kowalke.** (Amer. Electrochem. Soc., Trans. 24. pp. 377–389, 1913.)—Investigations were made on various thermo-couples which have recently come into use for industrial purposes and are made of metals such as iron and nickel and alloys of nickel, cobalt, etc. The object was to determine how the e.m.f. of the couples varied with the temperature and how its constancy was affected by successive heatings and coolings, and by exposure to various temperatures for extended periods of time. The couples tested were all compared with a Pt and Pt-Rh couple which had been standardised by means of a similar couple certified by the Bureau of Standards. It seems from the experiments made that it is possible to obtain a base-metal couple which is reasonably homogeneous and will give indications of temperature which are sufficiently constant to meet the needs and requirements of the industries. For measurements of a greater accuracy than within 25° a higher grade of instrument is required. Manufacturers are not always sufficiently careful in thoroughly annealing couples to remove strains resulting from mechanical treatment. Once the couple has attained its permanent structure there does not seem to be much change in the e.m.f. J. J. S.

1115. *Thermoelectric Behaviour of Metals at Low Temperatures.* **G. Weitzel.** (Ann. d. Physik, 43. 4. pp. 605–622, Feb. 27, 1914. Abstract of Dissertation.)—The author employed a compensation method of measurement and obtained, even at low temperatures, a constancy within less than a hundredth of a degree. The thermo-e.m.f.'s of pure metals, as well as some alloys, were measured with reference to lead in the temperature region between 14° and 273° abs. Some metals were also tested in the annealed condition. From the measurements as well as the curves of the e.m.f. the values of dE/dT were calculated. While various kinds of the same metals may differ in their e.m.f.'s, their E, and especially their dE/dT, curves have usually the same characteristic appearance. Annealing does not usually change significantly the large e.m.f's., but with the smaller values its action is proportionately higher, as in the case of pure gold. The curves obtained indicate that with large e.m.f.'s dE/dT has a tendency to decrease. The curves lengthen so freely that for them the relation of Nernst holds, viz. $\lim_{T=0}(dE/dT=0)$. That with some metals with small e.m.f. the value of dE/T does not decrease in the observed region, depends probably on the fact, that with such thermo-elements the difference $(dE/dT)_{AB}$ may increase while the members $(dE/dT)_A$ and $(dE/dT)_B$ follow Nernst's relation and with falling temperature will become smaller $[(dE/dT)_{AB}=(dE/dT)_A-(dE/dT)_B]$. At yet lower temperatures the measured $(dE/dT)_{AB}$ will probably first follow the heat law of Nernst, *i.e.*, dE/dT will fall off to $\lim_{T=0} dE/dT=0$. J. J. S.

1116. *E.M.F. due to Temperature Gradient in a Metal.* **H. Hörig.** (Ann. d. Physik, 43. 4. pp. 525–554, Feb. 27, 1914.)—The author has applied the method of comparison of capacities, as used by Bijl in the measurement of contact potential, for the determination of the e.m.f. which arises from the unequal heating of different portions of a metal rod or wire. The metals examined were silver and nickel, and it was found that the e.m.f. between warm and cold Ag or Ni in the temperature-range of 20° to 150° C. does not exceed the limits of $\pm 3{\cdot}5\times 10^{-5}$ volt per degree of temperature difference. The hot metal was placed in a vacuum of 10^{-3} to 10^{-6} mm. Hg. J. J. S.

1117. *Calibration Tables for Thermo-elements.* **L. H. Adams.** (Amer. Chem. Soc., Journ. 36. pp. 65-72, Jan., 1914.)—Two tables are given for use with copper-constantan and platinum—platino-rhodium thermo-elements. These will save much trouble in converting microvolts into degrees. In the case of copper-constantan the table was calculated from the equation $E=74{\cdot}672\,t-13892(1-e^{-0{\cdot}00261t})$, where E is the e.m.f. in microvolts, t the temperature (Centigrade) and e the base of natural logarithms. The Pt—Pt-Rh Table was calculated in three sections : the first from an exponential equation of the form $E=At+B(1-e^{Ct})$; the second from the equation

$$E=-308+8{\cdot}2294t+0{\cdot}001649t^2;$$

and the third by inverting the table of Sosman. J. J. S.

1118. *Thermal Electromotive Forces in Oxides.* **C. C. Bidwell.** (Phys. Rev. 3. Ser. 2. pp. 204–216, March, 1914.)—Various observations have previously been made by Seebeck and others on the e.m.f.'s across junctions composed of oxides, sulphides, silicates, and other compounds, but attempts have not been made to study prepared specimens of oxides or other compounds of known chemical purity. This paper is a preliminary attempt to plot e.m.f.-temperature relations and to determine the thermoelectric lines for oxides and other compounds. Further details on some points have yet to be obtained. In the experiments pure oxides were fused where possible in the oxy-hydrogen flame or baked into hard rods. The results are given in tables and curves. The thermoelectric diagram obtained shows that the Tait diagram may be extended to include the oxides. Also the thermoelectric powers for the oxides are of far greater magnitude than for the metals. Values above 1000 microvolts per degree are recorded for some oxides, while for the metals a value of 120 microvolts per degree is extreme. On the diagram for the oxides, as in the Tait diagram for metals, thermoelectric powers are high where resistances are high. The oxides examined include Fe_3O_4, CuO, V_2O_5, WO_3, ZnO, CdO, Cr_2O_3, Co_3O_4, SnO, NiO, Bi_2O_3, Mn_2O_3, and PbO. J. J. S.

1119. *Thermal E.M.F. between Metals and Metallic Oxides.* **S. L. Brown.** (Phys. Rev. 3. Ser. 2. pp. 239–240, March, 1914. Abstract of paper read before the Amer. Physical Soc., Dec., 1913.)—It was found that a considerable e.m.f. is generated when a cold wire is brought in contact with a similar or dissimilar hot wire. These e.m.f.'s are due to the oxides formed on the heated metals and were measured in some cases. For a copper and copper-oxide couple the thermoelectric equation would be fairly accurately expressed by the parabola $E = 0{\cdot}105t + 0{\cdot}00175t^2$, where E is in millivolts and t in degrees Centigrade. The results emphasise the necessity of close contact between the metals of any thermo-couple, since a very small difference between the temperatures of the wires would produce erroneous results if an oxide separated the wires. An e.m.f. of half a volt or more can easily be maintained between two copper rods by heating one in a flame to redness and holding the rather sharp point of another large rod in contact with the oxide on the hot rod. [See preceding Abstract.] J. J. S.

1120. *Validity of the Thermodynamical Relations for the Peltier and Thomson Effects, and Galvano- and Thermo-magnetic Effects for Variable Conductors.* **G. Gottstein.** (Ann. d. Physik, 43. 7. pp. 1079–1100, April 2, 1914. Extract of Inaug. Dissertation, Freiburg, 1913.)—Substances whose number of free electrons per unit volume can be altered very considerably by temperature and other influences have been called variable conductors by Königsberger. Such substances show large Hall, Ettinghausen, Nernst, and Leduc effects, and are thus suitable for testing the electron theory of these effects. Again they show enormous deviations from Wiedemann and Franz's law, and if it is not permissible to apply the thermodynamical relations to metals because of the irreversibility introduced by heat conduction it will be less so for these substances. The substances used were molybdenum sulphide, silicon, and graphite. The Peltier-effect against copper (P) was measured by a method similar to that used by Barker [see Abstract No. 138 (1914)] with certain modifications as the specimens could only be obtained as short, thick bars. The thermoelectric power (E) against copper was measured. The relation $E = -P/T$ was found to hold within the limits of experimental error. The equation between the specific heat of electricity and dE/dT was only found to hold qualitatively, the deviations being of the same order of magnitude as for metals. It is thus concluded that the deviations for metals, and in fact for any substance, are not due to irreversibility produced by heat conduction, and hence the thermodynamical relations are valid, the deviations from them being experimental or due to some undiscovered effect. In spite of the large Hall-effect of variable conductors, its accurate measurement involves great care, for the Ettinghausen-effect accounts for a lateral temperature difference which produces thermoelectric currents. This can be eliminated in metals by using wires of the same material as the substances used. Both effects were measured in one series of experiments by having two wires (iron, eureka) from each lateral electrode to the galvanometer, and finding the current first with iron wires then with eureka. The results were in support of the electron theory as developed by Königsberger: (1) That the sign of the Hall-effect is opposite to that of the Thomson-effect; (2) that the ratio of resistance to Hall-effect is approximately a constant for substances which are only weakly para- or dia-magnetic. J. R.

1121. *Sudden Disappearance of the Ordinary Resistance of Tin, and the Superconducting State of Lead.* **H. K. Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 673–688, Jan. 29, 1914.)—Further information is now given relative to the superconducting state in pure tin [see Abstract No. 380 (1914)], and the investigation is extended to include lead and also amalgamated tin-foil. The sudden disappearance of resistance in the case of tin takes place at 3·806° K., the ratio of the resistance at 3·8° K. to that of 273° K. being $< 10^{-7}$; a threshold resistance is also observed, as with mercury. Thin wires (not circular) of lead, obtained by paring on the lathe, as in the case of tin, were also examined. The lead became superconducting, when immersed in liquid He, without it being necessary to reduce the pressure at which the helium boiled; at 4·29° K. the lead remained superconducting. It is not possible to say whether the resistance disappears suddenly, for there is as yet no satisfactory cryostat for the range from 14° K., where lead has its ordinary high resistance, down to 4·3° K., where the resistance has vanished. A threshold value for the current density in lead (bare wire 0·025 mm.^{2} section) showed that this is > 420 and < 940 amps./mm.^{2}, at 4·25° K. The phenomenon of superconductivity is then considered as regards its application in the production of resistanceless coils, having a great number of windings in a very small compass. The possibilities and limitations with ordinary conductors are first pointed out, Perrin's and also Fabry's conclusions being quoted, and it is then shown that with superconductors, assuming no detrimental effect due to the magnetic field produced, a coil with 9000 amp.-turns per cm. could be obtained by using a lead wire of 1/70 mm.^{2} section and winding this so that 1000 turns are obtained in 1 cm. in a layer 1 cm. thick (radial depth); resistance at ordinary temperature, 773 ohms. A current of 0·8 amp. could be sent through this, when in the superconducting state, without the threshold value being reached. L. H. W.

1122. *Dielectric Constants of Vapours.* **G. Pohrt.** (Ann. d. Physik, 42. 3. pp. 569–584, Oct. 16, 1913.)—Gives tables of results obtained by means of a method proposed by the late P. N. Lebedew, employing a Wheatstone bridge in which the balance that is disturbed by change in capacity due to change in pressure, is obtained again by shift of the slide-wire. L. H. W.

1123. *Resistivity of Molten Gold.* **E. F. Northrup.** (Frank. Inst., Journ. 177. pp. 287–292, March, 1914.)—At 20° C. gold is found to have resistivity of $2{\cdot}816_6$ microhms-cm. The method of measurement is similar to that described in Abstract No. 491B (1914). The material of the container must be fired to a temperature higher than that at which the measurement of resistivity of the molten metal is to be determined; otherwise there is contamination and error. At 1000° C. the gold was still solid, and its resistivity had become 12·54. At 1063° C. the resistivity increased from 13·50 to 30·82, as the gold melted. A curve is given, but its interpretation is reserved for a further paper. R. A.

1124. *Alteration of Electrical Resistance of Wires when subjected to Tension and Torsion.* **F. Credner.** (Zeitschr. Phys. Chem. 82. p. 457, 1913. Zeitschr.

Instrumentenk. 34. pp. 93–95, March, 1914.)—The increase which takes place in the electrical conductivity of metal wires under tension when raised to a temperature of about 500° C. is often explained by the assumption that there are two modifications of the metal, one amorphous, the other crystalline; the amorphous variety having the higher specific resistance. It is assumed that, by heating, the metal passes from the amorphous to the crystalline state. To this explanation Tammann has offered objections based on thermodynamical grounds. According to his theory three factors must be considered as tending to alter the conductivity: The formation of spaces between the individual crystalline units of the metal; the alteration of the structure of the metal cylinders in the case of wires under tension from an irregular to a suitably arranged system of crystallites; formation of spaces on the gliding surfaces of the metal. The present experiments show that in the temperature interval 100° to 300° C. the resistance at constant temperature sinks so much the quicker and further the higher the temperature. From a known temperature —which for Au is about 270° C., for Ag and Cu about 400° C.—a slow increase in the resistance begins. The minimum value of the specific resistance is reached at this temperature. An explanation of these facts according to Tammann's hypothesis is given. It is also found that the temperatures at which wires must be kept for 3 minutes in order to ensure the max. degree of conductivity are as follows: for Au and Ag, 480°; for Cu, 450°; for Ni, 550°; for Fe, 600° C. The results of these experiments help to confirm Tammann's views on the subject. A. E. G.

1125. *Electron Atmosphere* (?) *of Metals.* **C. R. Englund.** (Phil. Mag. 27. pp. 457–458, March, 1914.)—R. W. Wood advanced a theory of an electron atmosphere to account for some results which he obtained [see Abstract No. 865 (1913)]. In the present work measurements of the sparking potentials between silver, nickel, and soft-steel electrodes, one plane and the other having a radius of 1 cm., from ½ to 4 sodium wave-lengths apart, were made. The air film in every case remained an insulator until the voltage reached the sparking potential, when a charge passed over to the electroscope. It would thus seem that the hypothesis of an electron atmosphere is untenable.

E. H. B.

1126. *Characteristics of Crystal Rectification.* **A. E. Flowers.** (Phys. Rev. 3. Ser. 2. pp. 25–46, Jan., 1914.)—In view of the peculiarities noticed [see Abstract No. 143 (1910)] it seemed desirable to subject crystals to very low and very high frequencies to see if time or energy were required to build up a resisting film upon change of current to the direction giving the higher resistance. Also it seemed desirable to determine the magnitude of the rectification at the high frequencies used in wireless telegraphy. The low frequencies used in the present investigation were 60 ∾ and 2000 ∾; the oscillations ranged from 10^4 to $6{\cdot}8 \times 10^5$ ∾ per sec.

The results obtained are summarised briefly by the author as follows:—(1) The rectification at high frequency tends to be greater than at low frequency with the larger currents, and but very little different for small currents. (2) For very small currents the rectification tends to disappear, particularly for large contact areas and low current densities. (3) The rectification ratio for small currents is nearly proportional to the square of the rectified current and nearly proportional to the first power of the total or R.M.S. current. (4) Even very large contact areas will rectify well with large currents. (5) The rectification *ratio* for very small currents may be improved by the use of very small contact points, but a much larger potential is required to get the same amount of current. (6) The current density must be equal to or greater than a given minimum value for good rectification. (7) Resistance in series with the galena crystal rectifier greatly decreases the rectification ratio even for the same potential difference on the terminals of of the rectifier. At 2·5 volts the rectification ratio was 61 % at 60, ∿ and 63 % at 180,000 ∿. L. H. W.

1127. *Production of Critical Damping in a Moving Coil.* **P. E. Klopsteg.** (Phys. Rev. 2. Ser. 3. pp. 121–125, Feb. 1914.)—Assuming that the coil moves in a uniform field, two equations are developed for finding the proper size of wire to be used in damping rectangles, in order that critical damping may be obtained in moving-coil galvanometers. One equation is for use when the number of turns in the coil cannot be ascertained; the second when this number is known. It is suggested that manufacturers be requested to furnish, with their galvanometer coils, the values of the moment of inertia, number of turns and mean area of the coils. [See also Abstract No. 551 (1914).]

G. E. A.

1128. *The Moving Coil Ballistic Galvanometer.* **R. L. Jones.** (Phys. Soc., Proc. 26. pp. 75–81; Discussion, p. 81, Feb., 1914.)—The author first considers the mathematical theory of a moving coil galvanometer in which the damping is such as to make the motion non-oscillatory; then an account is given of some observations on a galvanometer which confirm some of the deductions from the theory, and the results obtained are applied to find the relation between the galvanometer throw and the change of flux in the search coil which produces it. AUTHOR.

1129. *Dielectric Constant of Air up to 350 Atmospheres' Pressure.* **A. Occhialini and E. Bodareu.** (Ann. d. Physik, 42. 1. pp. 67–93, Aug. 26, 1913).—The full paper corresponding to Abstract No. 1496 (1913).

1130. *Rails and Slider Magneto.* **A. Gray.** (Phil. Mag. 27. pp. 428–432, March, 1914.)—The author points out the almost universal neglect of the variation of the self-inductance in this apparently simple apparatus, and develops the requisite correction to the mathematical theory, noting also that the apparently less simple disc magneto is really more so, in that its self-induction is unchanged by the rotation. G. W. DE T.

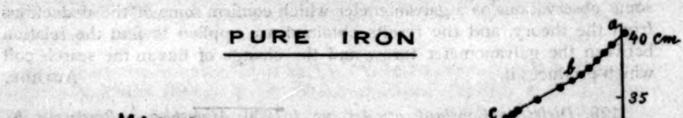
1131. *A Water Model of the Musical Electric Arc.* **W. Duddell.** (Phys. Soc., Proc. 26. p. 117, Feb., 1914.)

ALTERNATING CURRENTS AND MAGNETISM.

1132. *Permanent Magnets and Dynamical Theory.* **A. Gray.** (Phil. Mag. 27. pp. 432–435, March, 1914.)—Kelvin's conclusion [*Electrostatics and Magnetism*, p. 571, note] that the "mechanical value" of a current in a closed conductor is not affected by neighbourhood of permanent magnetism looks as if it must be inconsistent with the Amperean theory of permanent magnetism. The mathematical theory of a number of battery circuits in the field of a system of permanent magnets shows that, for a current system of moderate amount compared with the molecular current system, the effect, if any, of a configuration change in the former will be very small—this is a matter of observation. The effect of the magnets must be sought in the opening of the current circuits, and the effect, if any, of the annulment of terms expressing the interaction of current system and magnets will consist in a change in the magnets. For when the circuits are opened the tubes of magnetic induction through the circuits produced by the magnets are not changed (except in so far as the magnets are changed by the withdrawal of the tubes thrust through the molecular circuits by the battery circuits); they remain *in situ*, none of them cross the wires. The tubes, however, which the battery circuits have linked through the molecular circuits shrink and disappear, and cross these latter circuits in doing so. If practically no change in molecular currents, $\Sigma\Sigma M\gamma$ must be small in comparison with $\Sigma(L'\gamma')$, where γ refers to the battery current system and γ' to the molecular current system. Thus any change in a γ', due to the opening, must be of a small quantity of the order $M\gamma$ in magnitude, so that considering the exceedingly great number of molecular circuits in an ordinary magnet on the Amperean theory, the dynamical value of a current in a conductor will not be appreciably affected by the presence of permanent magnets. G. W. DE T.

1133. *Change of Magnetisation and Electric Resistance in Iron, Steel, and Nickel at High Temperatures.* **K. Honda** and **Y. Ogura.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 231–239, Feb., 1914.)—The above metals were formed into wire grids, which were held in cylindrical form by means of asbestos-paper binding. They were then tested simultaneously as regards resistance and magnetisation (by a magnetometric method) at different temperatures. The course of the phenomena is similar in iron and nickel. The nick *c* on the resistance-temperature curve *dcba* is considered as indicating

$l = 112{\cdot}0$ cm. $2r = 0{\cdot}71$ mm. $H = 160$



the end of the change of resistance caused by the ferromagnetic property of the metal (see diagram). No change was noted in the resistance of steel wires during the small magnetic change which takes place between 100° and 200°. Honda's view, that the magnetic or α-β change is not a phase transformation but a progressive change in the property of a phase with temperature, is confirmed by the experiments. G. E. A.

1134. *Cross Magnetisation made Visible.* **E. Liebreich.** (Deutsch. Phys. Gesell., Verh. 16. 6. pp. 807–814, March 30, 1914.)—Faraday, and later Donle, demonstrated that permanent cross-magnetisation of a thin plate of iron or steel was practically impossible. In dealing with the magnetisation involved in the Poulsen telegraphone, the author has used a method of rendering visible the fine details of local longitudinal magnetisation. The iron or steel plate was first put in contact with a magnet, and then powdered with iron powder (*ferrum hydrogenio reductum*). The powder was knocked off, leaving only the very finest iron dust behind, and the plate then placed for a few minutes in a bath of chromic acid. The magnetised spots became dark red on a yellowish-red background. The equations representing the presumed chemical action are given along with further details of the method. G. E. A.

1135. *Magnetic Properties of Iron and Nickel.* **J. R. Ashworth.** (Phil. Mag. 27. pp. 357–370, Feb., 1914.)—This is the first part of a paper on the magnetic behaviour of Fe and Ni when the effects of hysteresis are largely got rid of by using an alternating current. The magnetometric method was used in the experiments. A continuous current could be applied to the solenoid and the alternating current used to annul hysteresis had a frequency of 88 per sec. In iron an alternating current of 1 virtual amp. was found to be sufficient to reduce the hysteresis to a negligible quantity without appreciably lowering the intensity of magnetisation at ordinary temperatures. Stronger alternating currents are required to suppress hysteresis in nickel, and a current of 2 virtual amps. or even currents twice as strong did not suppress hysteresis altogether. An account is given of the investigation of the law of inverse relationship between strength of alternating current and intensity of magnetisation; of the construction of anhysteretic isothermals and isodynamics for iron and nickel; and of the suppression of the critical temperature in Ni. The author considers the experiments indicate that it is unlikely that the critical temperature is due to a chemical or allotropic modification of the metal. Some of the curves obtained point to the occurrence of a gradual change from ferromagnetic to paramagnetic properties. As a first approximation the equation to the anhysteretic isothermals may be written $H(1/I - 1/I_0) = R'T$, T being the absolute temperature. When I is very small the term $1/I_0$ may be neglected and the equation then becomes $H/I = R'T$ or $KT = 1/R'$. P being the constant occurring in Fröhlich's equation $H(1/I - 1/I_0) = P$, $R' = P/T$, and K is the susceptibility. This is Curie's paramagnetic equation in which $1/R'$ is equivalent to his constant A. But there appears to be another field of force in action besides the external field, and this is probably due to the magnetisation of the material itself and is some function of the intensity. The equation would then take the form $(H + f(I)/1/I - 1/I_0) = R'T$. Thus it recalls the equation of van der Waals for fluids, field strength and magnetic intensity taking the place of pressure and density. Since the effects of temperature on magnetism are found to be like those due to an alternating current setting up a magnetic agitation, it appears more probable that the former are kinetic effects of thermal agitation. J. J. S.

1136. *Electromagnet to give a Field of* 100,000 *Gauss.* **H. Deslandres** and **A. Perot.** (Comptes Rendus, 158. pp. 658–664, March 9, 1914.)—By increasing the dimensions of the apparatus described in a former paper [see Abstract No. 756 (1914)] the authors hope to be able to produce a field of 100,000 gauss. G. E. A.

1137. *Susceptibility of Feebly Magnetic Alloys.* **E. L. Dupuy.** (Comptes Rendus, 158. pp. 793–794, March 16, 1914.)—Measurements were made by the use of Faraday's method in which the specimen is suspended between the poles of a strong electromagnet. The effect on the specimen was neutralised by an electromagnetic method similar to that of Weiss and Foex. The Sb-Ag susceptibility diagram has three angular points corresponding to the compound Ag-Sb and to two saturated solid solutions of this compound in Ag and in Sb respectively. The results for Pb-Sn agree with those of Honda and Sone. A diagram is also given for Al-Zn. In these alloys the susceptibility varies according to a linear law when the two constituents form a simple mixture; the variation is irregular for solid solutions; and definite compounds have definite susceptibilities. G. E. A.

1138. *Anomalous Temperature Effects in Magnetised Steel.* **N. H. Williams.** (Phys. Rev. 3. Ser. 2. pp. 115–120, Feb., 1914.)—A description of work undertaken to obtain further data on the anomalous magnetisation described by Smith and Guild [Abstract No. 1889 (1912)]. The experiments point to the conclusion that the outer layer of the steel rod is harder than the interior portions, and that the effect, on this layer, of the oscillatory current in the magnetising coil at break, in conjunction with the demagnetising field due to the ends of the rod, may produce a reversal of magnetism in the outer layers of the rod. G. E. A.

1139. *Ferromagnetic Manganese Phosphides.* **S. Hilpert** and **T. Dieckmann.** (Ber. Deut. Chem. Gesell. 47. 4. pp. 780–784, March 7, 1914. Chem. News, 109. p. 215, May 1, 1914. Abstract.)—The authors and O. Hauf heat 2 gm. of manganese and 2·4 of red phosphorus in an exhausted tube of Jena glass to 400°, and then to 600°, each time for 48 hours. The product extracted with benzene, alcohol, and ether, leaves a darkish-grey substance MnP_3, which is not attacked by acids free of oxygen, but slowly decomposed by nitric acid. Heated in a hydrogen current at 290° it remains constant; at 400° part of the phosphorus distils over, and the phosphide MnP (described by the authors in 1911) is left, which resembles the higher phosphide in appearance and reactions. Both these phosphides, as well as others previously prepared, Mn_3P_2 and Mn_5P_2, are ferromagnetic, the Curie point of the MnP_3 lying about 38°, that of the MnP about 28°. These temperatures are very low. H. B.

1140. *Modification in the Cryomagnetic Apparatus of Kamerlingh Onnes and Perrier.* **E. Oosterhuis.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 892–894, March 26, 1914. Communication No. 139*b* from the Phys. Lab., Leiden.)—The electromagnetic method of compensating the magnetic force on the specimen [see Abstract No. 969 (1914)] is here replaced by a compensation by means of weights. G. E. A.

1141. *Susceptibility of Solid Oxygen in two Forms.* **A. Perrier** and **H. K. Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 894–901, March 26, 1914. Communication No. 139*c* from the Phys. Lab., Leiden.)—Solid oxygen, besides appearing in the blue-grey form, also occurs in a transparent vitreous form. The method of obtaining a solid rod of oxygen having been detailed, the following results are given. The transition from the transparent modification of oxygen to the opaque, which takes place at about —225° C., is not accompanied by any conspicuous magnetic change. Also in the whole range from the freezing-point of oxygen down to about —240° C. the susceptibility is markedly less than in the liquid state. At about —240° C. the susceptibility suddenly falls to about half its value, viz. from $166{\cdot}1 \times 10^{-6}$ to 79×10^{-6}. There are thus two great changes in the susceptibility of oxygen, one a drop to $\frac{1}{3}$ at freezing, and the other to $\frac{1}{2}$ at —240° C. Oxygen therefore is a new example of a substance that follows Curie's law at a higher temperature, and on approaching the absolute zero completely deviates from it. G. E. A.

1142. *Susceptibility of Liquid Mixtures of Nitrogen and Oxygen.* **A. Perrier** and **H. K. Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 901–916, March 26, 1914. Communication No. 139*d* from the Phys. Lab., Leiden.)—A determination of the susceptibility of liquid mixtures of O and N was made for the purpose of gauging the influence of the distance of the molecules on the deviations from Curie's law. The following conclusions are drawn from the experimental results: The specific magnetisation coefficient of oxygen becomes greater in proportion as the concentration diminishes, *i.e.* the additive rule is by no means followed in mixtures of O and N. With increasing dilution, the magnetisation coefficient approaches to the values which satisfy inverse proportionality to the absolute temperature, starting from Weiss and Piccard's value for gaseous oxygen. The deviations from the Curie-Langevin law shown by pure O at low temperature are not an immediate consequence of the change of temperature, but are caused by the increase in density, that is, by the distance between the molecules becoming smaller. Further, when $1/\chi$ is plotted with T, the points obtained for different concentrations lie on parallel straight lines. The change can therefore be represented by a relation of the form $\chi(T + \Delta) = \text{const.}$, in which only Δ changes from one concentration to another. The change in the density of oxygen therefore only alters the specific magnetisation without changing the Curie constant. It is considered that Langevin's theory, supplemented by the hypothesis of negative molecular fields, is sufficient to explain the phenomena, and that the molecular field of oxygen changes nearly proportionally to the density. [See also preceding Abstract.] G. E. A.

1143. *Magnetic Susceptibilities of the Elements.* **F. H. Loring.** (Chem. News, 109. pp. 121–123, March 13, and pp. 133–134, March 20, 1914.)—A general account is given of magnetic susceptibility and of its relation to permeability, and an attempt is made to bring the magnetic properties of the elements into systematic relationship by making use of the arrangement of the elements previously developed by the author [see Abstract No. 98 (1914)]. T. H. P.

1144. *Extension of Mayer's Experiment with Floating Magnets.* **E. R. Lyon.** (Phys. Rev. 3. Ser. 2. pp. 232–238, March, 1914.)—Describes experiments with floating magnets illustrating J. J. Thomson's theory of the atom. Instead of a large magnet to attract the little magnets, a coil wound round the circular tank was used. Systems up to 75 floating magnets were tried, and results were obtained which accord with Mendelejeff's grouping of the elements. Still larger groups are to be investigated. E. H. B.

1145. *Hysteresis at High Frequencies.* **A. Schidlof** and **Mlle. A. Albert.** (Archives des Sciences, 37. pp. 117–132, Feb., 1914.)—Repetition of a previous research [see Abstract No. 1510 (1913)] with greater accuracy. The results confirm the conclusion of Guye and Albert that the loss of energy is independent of the speed of describing the hysteresis cycle. [See also Abstract No. 550 (1914).] G. E. A.

1146. *Theory of the Earth Inductor as an Inclinometer.* **N. E. Dorsey.** (Terrestrial Magnetism, 18. pp. 1–38, March, 1913.)

1147. *The C.I.W. Deflector in use on the "Carnegie" for determining the Magnetic Horizontal Intensity and the Magnetic Declination at Sea.* **L. A. Bauer** and **J. A. Fleming.** (Terrestrial Magnetism, 18. pp. 57–62, June, 1913.)

1148. *Absolute Susceptibility of Liquids.* **W. J. de Haas** and **P. Drapier.** (Ann. d. Physik, 42. 3. pp. 673–684, Oct. 16, 1913.)—The full paper corresponding to Abstract No. 690 (1913).

1149. *Magnetic Declinations and Chart Corrections obtained by the "Carnegie" from St. Helena to Falmouth, England, July to September,* 1913. **L. A. Bauer** and **W. J. Peters.** (Terrestrial Magnetism, 18. pp. 161–162, Dec., 1913.)

RADIOLOGY AND ELECTROPHYSIOLOGY.

1150. *New Methods of Localisation of Foreign Bodies by Röntgen Rays.* **G. Réchou.** (Archives d'El. Médicale, 22. pp. 75–91, Jan. 25, 1914.)—The three methods described are those of Mazérès, Furstenau, and Laroquette. The geometrical principle on which each of these methods is based is first of all explained in detail, then full descriptions of the procedure in each case is given, together with any slight necessary addition to the general explanation. In each of the methods use is made of the images of some object placed on the body of the patient, and the displacement of this image, as compared with that of the foreign body, is the fundamental measurement required. The tube used is either one of ordinary type, in which case a movement of the tube in a plane parallel to that of the photographic plate must be arranged, or a tube of the spectroscopic type. Special compasses for performing the measurement of displacements are also described. A. E. G.

1151. *Three Practical Methods of Localisation of Foreign Bodies with or without a Compass.* **Mazérès.** (Archives d'Él. Médicale, 22. pp. 281–292, March 25, 1914.)—The three methods described allow an automatic localisation, a localisation by varying the height of the bulb, and a manipulation by graphical means, neither instruments, tables, nor scales being required. The three methods verify each other, and the radiographic and mental work is reduced to a minimum. The theory common to all three methods is dealt with in detail. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1152. *Application of the Laws of Transparence of Matter to Röntgen Rays to the fixing of some Contested Atomic Weights.* **L. Benoist** and **H. Copaux.** (Comptes Rendus, 158. pp. 689–692, March 9, and pp. 859–860, March 23, 1914.)—As a result of the verification of the laws of transparence of matter in the case of complex minerals [see Abstract No. 869 (1914)] the method is now extended to carrying out control experiments in the determination of atomic weights of thorium, cerium, and glucinum. The method is based upon an absolutely intrinsic property of the atom and consists in determining the transparency equivalent of the element, experiments being made either upon the element itself or on one of its compounds. In the latter case the equivalent sought is deduced from that measured for the compound, those of the other components being known. The value obtained assigns to the element a certain position upon a general curve of isotransparence of the elements for the rays of the degree employed and, consequently, a certain atomic weight. A means of control is employed by comparing the element with those to which it is near, the comparison being made upon the value of the equivalent or upon the variations of transparence resulting from variations of radio-chromometric degree of the rays. This method has the advantage over those which are based upon the law of Dulong and Petit and those of a similar class, in being entirely independent of all conditions which bring about variations in the physico-chemical properties. In the case of thorium according as the normal valency is considered as 2 or 4 the atomic weight ought to be 116 or 232. It is shown that the transparence is compatible with an atomic weight 232, and this is confirmed by a direct comparison with Pb. With cerium the question to decide is whether the more probable atomic weight is 92 or 140·25. By a comparison of its equivalent of transparence with those of Zr, Mo, Ba, and La, it is concluded that the results are in favour of an atomic weight of 140·25 for Ce. Glucinum may, if bivalent, be considered to have an atomic weight 9·1, and if trivalent, one of 13·7. The present experiments give results in favour of the former. A. E. G.

1153. *Change of Form of Liquid Crystals caused by a Molecular Transformation.* **O. Lehmann.** (Comptes Rendus, 158. pp. 389–393, Feb. 9, 1914.)—In the "formes myéliniques" of ammonium oleate there exists a structure which is neither amorphous as in liquids nor reticular as in crystals: the molecules appear to be arranged in circles round an axis, so that points on and off the axis are not equivalent, nor is the axis itself equivalent to other lines parallel to it. Under a microscope these forms show curved filaments, whilst in the crystals the lines are all rectilinear; by varying the temperature above and below −4° the lines become curved and straight alternately; *e.g.* on cooling below −4° a perfect circle may be seen to become polygonal. Similar observations can be made with "protagon," a mixture of cerasine and phrenosine studied by O. Rosenheim and C. Tebb in the Physiological Laboratory at King's College, London. T. M. L.

1154. *Absorption of Gases by Charcoal at Low Temperatures.* **G. Claude.** (Comptes Rendus, 158. pp. 861–864, March 23, 1914.)—It is usually accepted as a general rule that the more easily a gas is liquefied, the more readily it is absorbed by charcoal [see Abstract No. 1658 (1908)]. Some observations of the author in connection with the filling of tubes with neon indicated that hydrogen was abnormal with respect to its absorption by charcoal, and he has consequently determined the amounts of various gases absorbed by 100 gm. of coconut charcoal at various pressures. With hydrogen, neon, and helium the temperature was —195·5°, and with nitrogen —182·5°. The absorption of the hydrogen was found to be abnormal, much larger quantities being absorbed than of neon. Helium is the least readily, and nitrogen the most readily absorbed. T. S. P.

1155. *New Chemist's Slide-rule.* **H. R. Lee.** (Metallurgical and Chem. Engin. 12. pp. 201–202, March, 1914.)—A description of a new type of slide-rule designed to meet the needs of chemists engaged in commercial analysis. The regular or front side of the rule shows the molecular symbols of 46 salts and 10 acids and bases on the A scale of the frame and a parallel list of these on the B scale of the slide. On the back appear the symbols of 42 elements and 37 oxides in place of the usual A scale on the frame, and a parallel list of these on the B1 scale of the slide. The C and D scales on the front and the C1 and D1 scales on the back are graduated numerically, as is usual on the engineers' slide-rule. The results obtained with the rule are of as high order of accuracy as the chemical work, which precedes its use, is usually expected to be. T. S. P.

1156. *Gran-Annular Electric Furnace.* **Z. Jeffries.** (Metallurgical and Chem. Engin. 12. pp. 154–157, March, 1914.)—The furnace of C. H. Fulton and W. A. Coursen consists essentially of two concentric tubes (of alundum or magnesia) forming an annular chamber for the granulated resistor—kryptol, carbon of the Carbon Co., or graphite of the Acheson Co. The crucible is stored within the inner tube, whose diameter is 2 in. The tubes are embedded in heavy graphite plates, to which the terminals are attached; outside are powdered magnesia and asbestos. From measurements made in such a furnace with the aid of thermo-couples it follows that the three resistor materials mentioned have all a negative temperature coefficient; in the kryptol the resistance dropped from 8·3 ohms to about 1 ohm per cub. in. as the temperature was raised to 1500° C., in the carbon from 5 to 0·5, in the graphite from 1·8 to 0·6; in the last case particularly the small fall of resistance with rising temperature seems mainly to be due to the better contact between the grains consequent upon expansion. A special rheostat for working the furnace on 110-volt circuits is also described. The resistance is increased by each heating, owing to the oxidation of some carbon, and the material has to be renewed after about 40 heatings up to 1500° C. H. B.

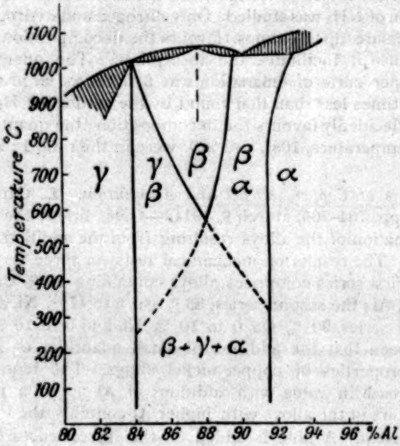
1157. *Preparation of Colloidal Sulphur and Selenium.* **J. Meyer.** (Ber. Deut. Chem. Gesell. 46. 18. pp. 3089–3091, Oct. 25, 1913. Chem. News, 108. p. 306, Dec. 19, 1913. Abstract.)—During his determination of the atomic weight of selenium, J. Jannek (Ibid. 46. p. 2876) observed that SeO_2 in aqueous solution is reduced only by highly diluted (not by concentrated) hydrazine hydrate; Se is very slowly precipitated in the red colloidal modification which quickly changes into the grey crystalline modification. When Se is dissolved in concentrated hydrazine hydrate, the author finds, it forms a viscous reddish solution which on high dilution yields an extraordinarily stable solution, which may even be boiled and be acidified; on long standing a little red Se falls out, which redissolves on shaking. Sulphur behaves similarly and yields a lemon-coloured solution, which turns yellowish-white, of colloidal sulphur; this solution is not quite so stable as that of selenium, and neither solution can be dialysed. The chemistry of these solutions is complicated, colourless sulphide (or selenide) and polysulphides being formed. H. B.

1158. *Decomposition of Gaseous Ammonia by Radium Emanation; Temperature Influence.* **E. Wourtzel.** (Comptes Rendus, 158. pp. 571–578, Feb. 23, 1914.)—The decomposition of H_2S-gas by radium emanation decreases when the temperature rises [see Abstract No. 764 (1914)]; this could be due to several reasons, one of them being that the recombination is favoured by higher temperature. To investigate this question the practically irreversible decomposition of NH_3 was studied. Only nitrogen and hydrogen are produced. Increased pressure (up to 7 atmos.) favours the decomposition, merely, it would appear, because it facilitates the absorption. The quantity of ammonia decomposed per curie of emanation was 8 times as large as that found by Usher, but 5 times less than that found by the author for H_2S. Elevation of temperature decidedly favours the decomposition; the quantities decomposed at ordinary temperature, 108°, and 220° were in the ratio 1 : 2 : 3. H. B.

1159. *Alloys of Copper, Nickel and Aluminium.* **L. Guillet.** (Comptes Rendus, 158. pp. 704–706, March 9, 1914.)—Gives briefly the results obtained by the examination of the alloys resulting from the addition of Al to copper-nickel alloys. The results of mechanical tests on three series of alloys are given. The first series comprises alloys containing 60 % Cu, 30 to 40 % Ni, and 0 to 10 % Al; the second series, 83 % Cu, 5 to 17 % Ni, and 0 to 10 % Al; and the third series, 90 % Cu, 0 to 10 % Ni, and 0 to 10 % Al. From the results it is seen that the addition of small quantities of Al improves the mechanical properties of copper-nickel alloys. The tensile strength and hardness increase in value with additions of Al up to a maximum. This maximum occurs in the alloys with higher Al-contents, the lower the amount of copper present. A note is added on the microstructure and the effect of treatment on the alloys. C. O. B.

1160. *Fusion and Volatilisation of Refractory Oxides in the Electric Vacuum Furnace.* **O. Ruff, H. Seiferheld, and J. Suda.** (Zeitschr. anorgan. Chem. 82. pp. 373–400, 1913. Tonindustrie Zeitung, 37. pp. 1693–1694, Oct. 30, 1913. Amer. Soc. Mech. Engin., Journ. 36. p. 05, Jan. 1914. Abstract.)—The melting-points of most refractory materials depend in a carbon furnace much upon the furnace atmosphere; only alumina, melting-point 2010 ± 10° C., is for this reason suitable for calibration purposes. Beryllium (glucinum) oxide stands next to alumina in that respect; it melts at 2525° under reduced pressure (10 to 30 mm.), but volatilises before melting. Zirconia is readily reduced to a lower oxide of melting-point 2585°, which is fairly independent of the atmosphere and the rate of heating, the vapour pressure being low. Magnesia melts above 2500°, but reacts too readily with carbon to allow of a definite temperature-determination. Lime reacts with nitrogen as well; it begins to volatilise about 2000°, though it does not melt at 2450° under reduced pressure. Stannic oxide melts in zirconia at 1625° under violent reduction. Titanium oxide is converted into Ti_7O_{12}; the oxides of tantalum and chromium are reduced to lower oxides; yttria, ceria, thoria, and lanthana are converted into carbides H. B.

1161. *Copper-Aluminium Alloys containing* 84 *to* 90 *per cent. Copper.* **H. Hanemann** and **P. Merica.** (Int. Zeitschr. Metallog. 4. pp. 209–227, 1913. Rev. de Métallurgie, 11. pp. 86–88, Feb., 1914. Extract.)—Although the alloys of copper and aluminium have been pretty well studied, the Cu-rich ones present certain difficulties which the authors have endeavoured to clear up by a metallographic study of annealed and quenched samples. In the range tested (84·7 to 91·8 % Cu), these alloys present features very similar to those observed in quenched and annealed steels. Acid ferric chloride solution attacks the constituents in the order, α, β, γ, while ammonaical cupric chloride attacks them in the reverse order. Slowly cooled samples show α on a groundwork of $\gamma + \alpha$ eutectoid, the structure not being affected by prolonged annealing at 485° C. On rapid cooling α separates in long needles similar in appearance to the acicular ferrite sometimes developed in hypoeutectoid steels. After slow cooling, samples hypoeutectoid with respect to Al show large needles of γ in a ground mass of $\alpha + \beta$ eutectoid. More rapid cooling develops the γ in the form of star-shaped crystals. Quenching experiments show that the rate of crystallisation of these alloys is very high. Quenched alloys with 84 to 86 % Cu show large plates of β with localised crystallisation of γ. The general structure indicates that β crystallises in the regular system. Between 86 and 88 % Cu the structure consists of γ with an acicular constituent, while above 88 % Cu there are indications of the β splitting up into $\alpha + \gamma$. The observed phenomena are summed up by the accompanying diagram. F. C. A. H. L.



1162. *Preparation of Sections of Fractures.* **A. Campion** and **J. M. Ferguson.** (Iron and Steel Inst., Journ. 88. pp. 885–888; Discussion, pp. 889–891, 1913. Engineering, 96. p. 890, Sept. 19, 1913. Mech. Eng. 32. pp. 295–296, Sept. 26, 1913.)—Particulars and examples are given of the method of making of a microscopic section through a fracture of a piece of steel in which a fusible alloy is cast in contact with the fracture surface and allowed to solidify there, so that in the cutting and polishing processes support is given at the edge of the steel, thus preventing the rounding of the edge and permitting of examination to the extreme edge of the section of the fracture. The preferred fusible alloy consists of: Bi, 50; Pb, 30; Sn, 25; and Zn, 8 per cent. The fracture to be examined is dipped successively in HCl solution of 1·1 sp. gr., then "killed spirits," then in the molten alloy, where it is held until it ceases to cause solidification of the alloy. After cooling the section can be cut through the steel and the alloy as desired. F. R.

1163. *Arsenical Compounds of Cadmium.* **S. F. Zemczuzny.** (Zeitschr. f. Metallographie, 4. pp. 228–247, 1913. Rev. de Métallurgie, 11. pp. 88–91, Feb., 1914. Extract.)—In applying the methods of thermal analysis to this system it has been found impossible to prepare alloys containing more than 70 atoms per cent. As, owing to the volatility of As. The equilibrium diagram shows two maxima, one corresponding to Cd_3As_2 at 721° C., and the other at 621° C. corresponding to the compound $CdAs_2$. Two eutectics, one consisting of practically pure Cd and the other (Cd_3As_2—$CdAs_2$) containing 55·5 atoms per cent. As, are formed at 320° and 610° C. respectively. The compound Cd_3As_2 undergoes a polymorphic transformation at 578° C. Since the compound $CdAs_2$ readily supercools it has been found possible to follow a metastable branch of the curve showing a Cd_3As_2—As eutectic at 526° C. and containing 62·5 atoms per cent. As. These results have been confirmed micrographically and by a study of the densities and atomic volumes. Cd_3As_2 has a density of 6·25 and a hardness somewhat less than 3·5 on Moh's scale, while $CdAs_2$ has a density of 5·86 and a hardness of 3·5 The hardnesses of Cd and As on Moh's scale are 2 and 3·5 respectively. F. C. A. H. L.

1164. *The Surface Tension of Mixtures.* I. *Mixtures of Partly Miscible Liquids and the Influence of Solubility.* II. *Mixtures of Perfectly Miscible Liquids and the Relation between their Surface Tensions and Vapour Pressures.* **R. P. Worley.** (Chem. Soc., Journ. 105. pp. 260–282, Jan., 1914.)—The author has determined, by the capillary rise method, the surface tension of solutions of aniline, phenol, and iso-butyl alcohol in water, at different temperatures, and points out that there is apparently a connection between the lowering of the surface tension of water and the solubility of the solute, the effect of addition of a solute to water being all the greater the lower the solubility of the solute. This behaviour the author finds confirmed also at higher temperatures.

In Part II. the author communicates the results of determinations of surface tension in the case of mixtures of benzene and ethylene dichloride, acetone and carbon disulphide, pyridine and acetic acid; and from the results obtained puts forward the three rules: (1) If at any given temperature the vapour pressures of mixtures of two liquids agree with the values calculated by the rule of admixture in molecular proportions, then at that temperature the surface tensions of the mixtures agree with those calculated by the formula $S = V_1S_1 + V_2S_2$. (2) If the vapour pressures are greater than those calculated, then the surface tensions are less than those calculated. (3) If the vapour pressures are less than those calculated, then the surface tensions are greater than those calculated. A. F.

1165. *Relationship between the Viscosity, Density, and Temperature of Salt Solutions.* **W. J. Walker.** (Phil. Mag. 27. pp. 288–297, Feb., 1914.)—Measurements of the viscosity of solutions of sodium chloride of different densities at 62·5° F. lead to the formula, $\mu = 0·00002265 + 0·0000428(\rho - 1) + 0·000228(\rho - 1)^2$, where μ represents the viscosity in F.P.S. units and ρ the specific gravity of the solution. With sodium and calcium chlorides it is found that, if μ/μ_0 is plotted against μ, where μ and μ_0 are viscosities at similar densities, an approximately straight line is obtained, so that $F(\rho) = A - B/\mu$. Putting this in the form $F'(\rho - 1) = A - B/\mu$, the value $\rho = 1$ gives $B = \mu'A$, where μ' is the viscosity of water at the temperature considered. Hence $F'(\rho - 1) = A(1 - \mu'/\mu)$. Tentatively it was found that $F'(\rho - 1)$ is of the form $(\rho - 1)^n$, where n lies between 1 and 2 for both solutions. On plotting $\log(\rho - 1)$ against $\log(1 - \mu'/\mu)$ practically straight lines are obtained, the values of n being 1·088 and 1·055 for sodium and calcium chlorides respectively. Measurements of sodium chloride solutions at 0°, 10°, 30°, 50°, and 100° C. show that n decreases proportionally with rise of temperature from 0° to 30°, after which its relative diminution is much less to 100°. Assuming n to vary regularly from 1·4 to 1·0 between 0° and 100°, the formula $(\rho - 1)^{1·4 - 0·004T} = A(1 - \mu'/\mu)$ is obtained for sodium chloride solutions. Similarly, the expression, $(\rho - 1)^{0·96 - 0·008T} = A(1 - \mu'/\mu)$, is deduced for calcium chloride solutions between 0° and 50°. To obtain the value of A, it is best to use the point at which the solution has its highest density; for sodium chloride, $\log A = 0·6790 + 0·00874T$, and for calcium chloride, $\log A = -0·8580 + 0·0005T$.

In some cases the viscosity at first diminishes to a minimum as the salt-content of the solution increases, and then increases as usual. This happens with ammonium nitrate, and it is here found that good agreement is given by the formula, $\pm(\rho - x)^n = A(1 - \mu'/\mu)$, where μ' is the minimum viscosity and where the negative sign is used when x, the density at the minimum viscosity point, is greater than ρ. One reason for the diminution of n with rise of temperature is that the particles of the solute become more nearly analogous to gas particles, *i.e.* move with greater freedom at the higher temperatures.

With water and mercury, $F(\mu)$ in the formula, $F(\mu) = a - b/T$, is not of the form μ^n. T. H. P.

1166. *Solubility of RaEm in Aqueous Salt Solutions.* **M. Kofler.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1478–1479, July, 1913.)

1167. *Compressibility of Methyl Chloride.* **E. Bodareu.** (Accad. Lincei, Atti, 23. pp. 491–498, April 5, 1914.)—At 16·8° the variation of pv with p for methyl chloride is shown by the following table :—

p	760	1200	1650	2100	2800
pv	1	0·9796	0·9648	0·9538	0·9335

T. H. P.

1168. *Constitution and Structure of the Elements.* **H. Collins.** (Chem. News, 109. pp. 26–28, Jan. 16, 1914.)—The paper deals with empirical relations between the atomic weights. It is concluded that Na and Zr take a prominent part in the formation of all elements of greater atomic weight than themselves. E. M.

1169. *Conductivity of Fluosilicic Acid and Lead Fluosilicate.* **T. A. Patterson.** (Metallurgical and Chem. Engin. 11. pp. 670-672, Dec., 1913.)—Tables are given showing: (1) The conductivity and equivalent conductivity of fluosilicic acid at 25° C.; (2) the temperature coefficient of the conductivity of normal and sixteenth-normal fluosilicic acid from 20–45° C.; (3) the conductivity of various mixtures of fluosilicic acid and lead fluosilicate at 25°. T. S. P.

1170. *Hydrogen Electrode, Calomel Electrode, and Contact Potential.* **C. N. Myers** and **S. F. Acree.** (Amer. Chem. Journ. 50. pp. 396–411, Dec., 1913.)—Experiments have been made to establish the hydrogen-electrode as a standard instrument for measuring hydrogen-ion concentrations. Special attention is directed to the necessity of keeping the electrodes permanently wet after platinising; of maintaining them in an *active* condition during the whole time when they may be required for use; of saturating the system completely with hydrogen; and of avoiding all impurities in the acid used in the cell. It was found possible to get the (17) electrodes to agree within 0·00001 volt. If a large number of cells are connected with each other through the mercury in the electrode tubes they very soon settle down to give identical and normal values, and may agree within 0·000008 volt. This method may also be applied to the calomel electrode, enabling new batteries to come to agreement within 0·00001 volt in about 2 days, where otherwise 5 days may be required. The constancy of the hydrogen electrode has been proved over a period of nearly two years, but there is a certain amount of lag in responding to changes of barometric pressure (0·001 atmo. ≡ 0·000025 volt). The calomel electrode, on the other hand, shows a gradual shift in its value as its age increases, at least up to a year. This is attributed to decomposition of the calomel, $Hg_2Cl_2 \rightleftharpoons HgCl_2 + Hg$, and experiments are in progress to test the effect of adding mercuric chloride to the new cells.

Bjerrum's "sand-filling" method was tried and found to be very satisfactory. T. M. L.

1171. *Electrostatic Determination of the Potential of an Electrolyte.* **G. Borelius.** (Ann. d. Physik, 42. 6. pp. 1129–1144, Dec. 23, 1913.)—Use is made of a novel potential multiplier, consisting of a fixed and a revolving system, turned by hand. Six copper sectors attached to an ebonite disc pass over a glass cylinder containing the electrolyte and over two insulated copper plates mounted in a zinc cylinder; the rotating sectors touch the surface of the electrolyte and six brushes, which are joined to the zinc or to the plates and to a quadrant electrometer; a compensation method is used, the electrode dipping into the electrolyte being charged until the electrometer is no longer deflected. With a Cu-electrode dipping into normal $CuSO_4$ solution, the electrolyte potential was first + 0·2 volt, but it changed to − 0·028 volt in an hour; on diluting the normal solution to $N/2$, $N/2^3$, $N/2^7$, the potential steadily decreased to − 0·088 volt, the ΔP being nearly constant. These values are not in accord with those of other observers, nor with Nernst's formula; but the constants are the same, though of opposite sign. The author therefore suggests that not only the positive ions given off by the metals, but also the negative ions have to be taken into consideration in calculating single potentials. The paper also brings potential measurements of solutions of alkali salts, diluted in the above indicated way, KCl, KBr, KI, KCN against electrodes of various metals; in normal KCN the voltaic series found was Al, Zn, Cu, Cd, Sn, Ag, Sb, Pb, Bi, which agrees with Poggendorff, 1848. Normal solutions of KNO_3, K_2SO_4, NaF gave with different metals almost the same potentials as with pure water; the halide solutions gave more positive potentials. H. B.

1172. *Electro-deposition of Zinc at High-current Densities.* **J. N. Pring** and **U. C. Tainton.** (Chem. Soc., Journ. 105. pp. 710–724, March, 1914.)—At certain very high-current densities, the electro-deposition of zinc can be effected in the presence of a high concentration of free acid. Under these conditions the ratio of zinc to hydrogen liberated actually increases with the acid concentration up to a certain value, and also increases with the current density. In this way, with a concentration of sulphuric acid of about 15 gm. per 100 cm., and a current density of between 20 and 50 amps./dm.^{2}, zinc can be deposited with an efficiency of about 95 per cent. With lead anodes, this electrolysis is achieved with a p.d. of about 5 volts, and with zinc anodes, 8 volts. The presence of small quantities of colloidal matter exerts a marked effect on this reaction, and enables bright adherent deposits to be produced. Their presence also enables one to use a higher current density, and in this way yields a higher current-efficiency in the zinc deposition. In the solutions used a very strong retardation was observed in the deposition of iron present in the electrolyte, in all cases the amount of iron deposited with the zinc being very much less than the ratio of these metals in the electrolyte. On account of this considerable quantities of iron in the electrolyte caused very little contamination of the zinc. Experiments showed that the results obtained could not be entirely ascribed to effects of overvoltage, or surface tension, or viscosity of the electrolyte; they are probably mainly determined by influences which control the rate of the reactions involved in the change from the ionised to the free element. The results obtained by the authors indicate the most favourable conditions under which zinc can be obtained from commercial solutions, either with a view to the recovery of the metal or to its application for the purpose of electro-plating. T. S. P.

1173. *Electrolytic Reduction of Carbon Dioxide and Carbon Monoxide under Pressure.* **F. Fischer** and **O. Prziza.** (Ber. Deut. Chem. Gesell. 47. 1. pp. 256–260, Jan. 24, 1914. Dissertation of O. Prziza, Techn. Hochsch. Berlin, 1913. Chem. News, 109. p. 132, March 13, 1914. Abstract.)—The electrolytic reduction of CO_2 at ordinary pressure had been obtained by A. Coehn and H. Jahn, and also by Ehrenfeld. The authors proceed like the former, using their own apparatus designed for the reduction of dissolved oxygen. The CO_2 is passed through solutions of potassium sulphate (also Na- or Li-sulphate); the current yield is better with zinc than with copper kathodes, and still better when copper is coated with zinc, then amalgamated and kept polished; lead kathodes after Tafel also give excellent results, but only when the anode is also lead (not a Pt-wire as in the other cases). Working with a steel bomb at 15 atmos., again with a saturated solution of K_2SO_4, nearly theoretical current yields are also obtained with currents of from 10 to 15 amp./dm.^{2}; the product is formic acid or potassium formate, but the concentration is weak, because the electrolysis has to be stopped after about 10 minutes lest the formic acid anion migrate into the anolyte. The reduction of CO, dissolved under 100 atmos. in alkaline, neutral or acid electrolytes, did not succeed with electrodes of Ni, Fe, Cu, Hg, Pt, Ir, Zn. A little formate was produced in alkaline solutions, but simply by chemical reaction; with Pb kathodes a little methyl alcohol was found, but the current density had to be low, and the yield was very poor. Methane was not observed. H. B.

1174. *Rapid Determination of Zinc in Minerals.* **S. Zublena.** (Accad. Sci. Torino, Atti, 8a. pp. 148–164, 1913–1914.)—The author has adapted the method and apparatus of Frary [see Abstracts Nos. 189 and 190 (1908)] to the rapid determination of the zinc-content of minerals. For the details of the operations the original must be consulted. T. H. P.